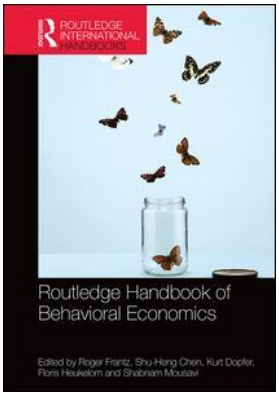

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GENERATING MESO BEHAVIOUR

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Introduction

In this chapter I will discuss a particular kind of economic behaviour that is not an integral part of the homo oeconomicus model. This behaviour is called meso because it is neither part of micro- nor of macroeconomics alone and it is shaped systemically through interactive socioeconomic associations. Thereafter, meso is characterized through structure as well as process components of dynamic change. In the second section I will identify some prototypic descriptions of such behaviour in the work of T.B. Veblen and J.A. Schumpeter in order to motivate an analytical discussion for generating meso behaviour. These prototypes include the instinct of workmanship and innovative entrepreneurship, as well as financing the means of the latter. It is argued that meso behaviour transforms the economy from within (i.e., leading to structural change including the possibility of economic crisis). However, the aforementioned scholars did not have analytical tools that were effective to translate these narratives into didactic analytical models. For this very reason, appropriate concepts and tools are discussed in order to ease the involved complexities for generating meso behaviour in models and simulations.

In the third section the chances and pitfalls of equilibrium, as well as rule-based approaches are highlighted in respective modelling attempts. It turns out that both of these analytical approaches lack systemic conceptions to meet the demands raised in the previous motivation. Therefore, I go beyond a rules-in-equilibrium approach and will discuss the meso framework originally developed by Dopfer et al. (2004). Structure as well as process rules are involved in the dynamic generation of meso behaviour, as proposed by Ostrom (2005) as well as Dopfer and Potts (2008). These rules work simultaneously on a horizontal (structure) and a vertical (process) axis, allow multiple associations between heterogeneous economic agents and relate agent systems to each other. An emerging meso unit corresponds to one of such potential networked systems that cannot be specified per se as an institution or as a social structure but involves agency and creative/adaptive response to changes in its environment. In this section I will compare the analytical concept of a meso unit (Dopfer et al., 2004; Dopfer and Potts, 2008) and that of a meso-sized interaction arena (Elsner, 2010; Elsner et al., 2015). The former takes an evolutionary economic approach and emphasises the innovation of generic rules. Once a novel rule originates in a micro agent, is carried and adopted by a share of the whole population, I speak of a meso unit as the generic rule and its carrier population. The latter draws otherwise

on the concept of complexity where meso behaviour emerges from coordination in social-dilemma type situations.

In section four I will follow Simon (1987) and show that the Veblenian and Schumpeterian agents are not be understood as optimizing but as satisficing agents, a precondition for micro behaviour enhancing meso-structured behaviour thereafter. This notion makes a theory of meso behaviour intelligible to us, since it is not the behaviour of the representative agent transforming the economy but the (de)coordination of heterogeneous satisficing agents that are assigning agency to a meso unit through shared characteristics eventually. To model and generate meso behaviour on behalf of satisficing behaviour, it is suggested to combine evolutionary and complexity foundations as highlighted by Simon (1962). In this modular framework I will emphasise the role of intermediate stable complex forms such as meso units. The bounded rationality of involved agents drives them to collaborate in modular meso units to change the economy in response to emerging novel needs. As a consequence, imitation, adaptation, innovation as well as resistance gain a central role in this behavioural economics.

Agents are computationally designed in this respect and feature characteristics as emphasised by Gilbert (2008). In this final section I will emphasise that meso behaviour can be generated and modelled via the agent-based methodology. Agent-based modelling is considered as a generativist approach by Epstein (2006), a methodology featuring the growing of artificial worlds in algorithmic form from bottom up. Meso behaviour can be modelled as an irreversible and path-dependent process by linking micro with macro. Finally, I will emphasise the potential of this approach in inventing a new kind of agent-based meso-founded macroeconomics, compare Dosi et al. (2010), Ciarli et al. (2010), Cincotti et al. (2010), Delli Gatti et al. (2011), Chen et al. (2014) as well as Rengs and Wäckerle (2014). The final fifth section concludes.

Prototyping meso behaviour: Veblen and Schumpeter

This section will introduce the central prototypes of meso behaviour in relation to the Veblenian and Schumpeterian conceptualization of economic behaviour. Veblen and Schumpeter have highlighted economic behaviour in a systemic and to some degree evolutionary perspective that is alien to the homo oeconomicus model, foremost because preferences are formed endogenously via social interaction. This aspect alone involves complexities for modelling and simulation that we confront in this book chapter. Social learning, imitation, innovation and local adaptation are central tenets of meso behaviour and make it time and space dependent. It is important to address that we understand a meso unit as sufficiently autonomous to behave in its own right and that it is capable of agency. Meso behaviour triggers systemic feedbacks on the micro behaviour of the agents involved, on other associated meso units and their structural relations that are composing macro (the whole economy) thereafter. Veblen and Schumpeter had the most significant influence in this regard and it seems appropriate to take a closer look into their picture of human behaviour.

In general, Veblen's theory (especially Veblen, 1899) takes an approach to economics where social values are central for the creation of behavioural patterns and their interconnections (Bush, 1987: 1078). In this anthropological system of thought, Veblen identifies two types of habitual culture in the American society of his times. There is the pecuniary interest of status-seeking imitation, on the one hand, and the industrial interest in the common production of commodities, on the other hand. He associates the former with ceremonial proclivities to be found in the business class and the latter with instrumental or technological proclivities to be found in the industry class. In this regard there are two institutional systems considered, "they are institutions of acquisition or of production . . . they are pecuniary or industrial institutions" (Tool, 1977: 827).

These proclivities are conceived as instincts by Veblen, which can be either supportive in terms of progress as in the case of the "instinct of workmanship", "parental bent" or "idle curiosity" or obstruct constructive properties along "practices of exploit, prowess or mastery (warfare), ownership (material acquisition), and in pecuniary control of industry" (Tool, 1977: 825–6). The instrumental values of the industrial arts are driving technological progress and let society prosper for the common good. The ceremonial values of the business enterprise drive economic behaviour into status-seeking lock-ins and, thereby, lead to inertia of technological and consequential institutional change. This type of dialectics lead to conflicting behaviours that are subject to evolving power relations (Samuels, 1995: 571), such as the habits of conspicuous leisure, consumption and waste (Veblen, 1899: 63–4).

In terms of meso behaviour, it is the habits of thought in the industry class that lead to an emergent meso unit and its further stabilization. "These include 'idle curiosity,' which in industrial society signifies critical inquiry, 'the parental bent,' which means altruism, and 'the instinct of workmanship,' which denotes taking pride in and obtaining gratification from the craftsman like performance of work" (Sheehan and Tilman, 1992: 200–1). These habits of thought are enhancing micro behaviour that enables the emergence of meso. However, they are not conceptualized as constant ends, they are rather part of an "ends–means continuum" (ibid.). For instance, altruism cannot represent a behavioural end in constant terms, once established it becomes a new means for a different end, such as individual well-being, social welfare or sustainable development. Nevertheless, for Veblen it is the instinct of workmanship that has the most significant impact on meso behaviour.

> This alien factor is the instinct of workmanship. Other circumstances permitting, that instinct disposes men to look with favour upon productive efficiency and on whatever is of human use. It disposes them to deprecate waste of substance or effort.
>
> *(Veblen, 1899: 64)*

The instinct of workmanship brings us a step closer to Schumpeter with a similar vision about human behaviour in an industrial society. Innovative entrepreneurship generates meso behaviour that is creative but also destructive (Schumpeter, 1942: 82–3). Schumpeter studied the evolution of capitalism as civilization and his analysis breaks with the rather static description of economic behaviour within the circular flow. There are roughly two institutions that are significant for generating meso behaviour, the first refers to economic behaviour as entrepreneurial action and the second to financing the means to this action. Entrepreneurship is understood as the "carrying out of new combinations" (Schumpeter, 1934: 66) that is a "lasting condition" till the business is settled and not subject to social class.

> Because being an entrepreneur is not a profession and as a rule not a lasting condition, entrepreneurs do not form a social class in the technical sense, as, for example, landowners or capitalists or workmen do. ... It can also put its stamp on an epoch of social history, can form a style of life, or systems of moral and aesthetic values; but in itself it signifies a class position no more than it presupposes one.
>
> *(Schumpeter, 1934: 78)*

Therefore, the entrepreneur is substantially different from the homo oeconomicus in terms of behaviour. Quite similar to Veblen, Schumpeter insists on creativity, curiosity but also on a motive "to succeed for the sake, not of the fruits of success, but of success itself" (Schumpeter, 1934: 93) as central drivers of innovative behaviour striving for novelty. The entrepreneurial agent represents the focal source for generating meso behaviour, because it is dynamically

breaking with existing standard behaviour and traditions. This kind of innovative behaviour is by far not of stochastic nature, on the contrary it is about choice. Hanappi (2008) argues that strategic interaction plays a dominant role for innovative behaviour because it depends on the communication of different mental models that indicate inputs for choices eventually. Innovative behaviour is subject to the social mediation of meso thereafter, a notion emphasising the Marxian roots of Schumpeterian thought. Meso behaviour is generated within power relations, where individual contradictory choices enforce the emergence of novelty. This idea of meso behaviour relates to the significance of a heterogeneous conception of economic agents that I will emphasise in section three. Consequently, modellers have to make explicit assumptions about information and communication within and between heterogeneous agents.

The commonality between Veblenian and Schumpeterian economic behaviour relates to the creative enhancement of meso-structured behaviour by the "socially shared imagination" (Dopfer, 2004: 190) or more generally by the development of a "common consciousness" (Hanappi, 2008: 2079). Complementarities in Veblenian and Schumpeterian meso behaviour have led to significant innovations in the history of capitalism. The most important were established by combining the usage of a new source of energy with a new a medium of communication. Examples are given by the use of coal for the steam engine and the development of steam-powered printing presses that have considerably enhanced literacy among all social classes. Another example is given by the use of fossil fuels in the combustion engine and the development of broadcast communication such as radio and TV. This combination has led to the Fordist accumulation regime of mass production and consumption, responsible for the after war boom in economic welfare. Foster (2011) shows how such complementarities have driven the development of capitalism by the collective usage and co-evolutionary relationship between new knowledge stemming from novel media and free energy. The behavioural response to this "autocatalytic interaction" is given by evolving "units of identification" (ibid: 94–6) forming on behalf of newly developed aesthetics and thereby generating novel meso behaviour. Foster (2011: 98) argues that aesthetics connects "energy throughput and the application of knowledge" and this process of economic structuration leads to "the reduction of accessible free energy gradients" (ibid.: 88). This hypothesis is considered as foundational for economic behaviour and relates to the problem of economic growth and sustainable development.

The "dilemma of growth" (Jackson, 2011: 49–66) has evidently shown that not every kind of innovation is beneficial and that innovative behaviour needs to be appraised in terms of energy usage, biodiversity loss, carbon emissions and environmental pollution. Jackson (2011: 87–102) emphasises that the complementarities of Veblenian and Schumpeterian economic behaviour may lead us into an "iron cage of consumerism", a state that is similar to a technological and institutional lock-in. To avoid such lock-ins, many authors argue in favour of installing and deploying a third industrial revolution built on novel meso behaviour. Perez (2013) argues that this time of multiple crises needs the "installation and deployment of a new golden age" (ibid.: 10–12), that is combining the usage of renewable forms of energy—such as solar and wind energy—with the use of novel information technology (i.e. the Internet). The most crucial role in this evolutionary economic project is probably given by global finance as indicated by Perez (2013: 13–15), who considers Minsky (1986) as a third complementarity in this regard.

Minsky argued that "Our economy is unstable because of capitalist finance" (Minsky, 1986: 244). Instability emerges endogenously in prosperous times of tranquil stability where margins of safety decline or even erode. Central to Minsky's theory of financial behaviour is the speculative motive that was originally introduced by Keynes (1936: 126) in his theory of endogenous money. In this view "money is created in the process of financing investment and positions in capital assets" (Minsky, 1986: 131). Schumpeter (1934) developed a very similar view on money where banks create purchasing power in order to finance innovative behaviour.

> This method of obtaining money is the creation of purchasing power by banks. ... It is always a question, not of transforming purchasing power which already exists in someone's possession, but of the creation of new purchasing power out of nothing ...
>
> *(Schumpeter, 1934: 72–3)*

Minsky owes his analytical precision both to Keynes and Schumpeter (Knell, 2015), he could truly master a synthesis of these two great economists and could explain why Schumpeter could not develop a full-fledged endogenous theory of money. In many respects Hyman Minsky has anticipated the role of herding behaviour in destabilizing the economy. Basically, a Schumpeter–Minsky meso unit consists of complementary micro behaviours of entrepreneurs and bankers that are providing the financial means for innovative behaviour, but this meso unit may quickly destabilize the economy if speculative or Ponzi schemes are adopted by a larger group of agents. The necessary choices for generating a meso unit are made under true uncertainty and this "is largely a matter of dealing today with a future that by its very nature is highly conjectural" (Minsky, 1986: 207).

Analysing meso behaviour: equilibria, rules and meso

The previous section has discussed prototypes of meso behaviour in the work of Veblen and Schumpeter. Their models have remained in the realm of prose, certainly within the more thought-provoking chapters of economic prose filled with grand pieces of ironic satire. Still, they build up scholarly entry barriers for students of economics as well as applicants of economic theory. To this extent, the aim of this section is to emphasise concepts that make meso behaviour intelligible to us and can bridge between semantic content, analysis, modelling and simulation.

The previously discussed problem structures can neither be associated solely with micro nor macro approaches, thereby they demand an intermediate level of analysis such as meso. A traditional way of addressing problem structures of this type is followed in institutional economics (Hodgson, 2004). Institutions are diverse, ubiquitous and manifold (Ostrom, 2005), who involve processes of social valuation and thereby evolve, since values are not constant ends. Hodgson (2015: 501) defines institutions as "integrated systems of rules that structure social interactions" and provides thereby a necessary working definition and "demarcation criterion to distinguish institutions from other social phenomena" (ibid.). The notion of "shared systems of rules" (ibid.) is essential in this regard and an interesting approach was developed by Masahiko Aoki (2001: 10), who articulates a game-theoretical approach and characterizes an institution as a "self-sustaining system of shared beliefs". In this conceptualization the author incorporates a "rules-in-equilibrium" approach (Hindriks and Guala, 2014) with special attention to the "rules of the game" as the

> way by which the game is repeatedly played ... We regard these rules as being endogenously created through the strategic interactions of agents, held in the minds of agents, and thus self-sustaining – as the equilibrium-of-the-game theorists do.
>
> *(Aoki, 2001: 10)*

The unique criterion in this approach is given by "repeated games" where pairwise interaction gains dynamic momentum, albeit Aoki (2001: 185–206) does not use a generative bottom-up but a closed-form evolutionary game theory approach (see also Bowles, 2004). Hodgson (2015: 500) considers this attempt fruitful since "the resulting game equilibria themselves establish possible rules" and thereby link to processes in contrast to deterministic outcomes. The advantage of

Aoki's (2001) approach to institutional change and more generically to meso behaviour is given by its analytical tractability:

> One of the great advantages of this equilibrium-based approach to institutions is that it becomes analytically tractable to deal endogenously with types of institutions that may emerge across different domains as well as possible interlinkages among institutions.
>
> *(Aoki, 2001: 207)*

Aoki (2001) has shown how we can apply this methodology in static terms to a diversity of real-world problems, ranging from governance, finance, to innovation. The issue of finance is, for instance, analysed as a topic of "relational-contingent governance" (Aoki, 2001: 307) in the context of the Asian banking crises in the 1990s, especially the case of Japan. Concerning Japan, I speak of the emergence of a rather stable and subsidized (see also Pagano, 2011: 387) firm–bank network on behalf of cross-shareholding and a main bank system in the second half of the twentieth century. This system emerged out of organisational disequilibrium and has reduced uncertainty to provide the means for innovative activity, job security as well as purchasing power. Aoki (2001: 329) highlights that institutional stability depends on "institutional complementarities and co-emergence", institutions that are already existing or co-emerging in order to sustain the performance of an institution, understood "in the economist's language as unintended subsidies coming from different selection domains" (Pagano, 2011: 377).

The concept of "interlocking complementarities" is not just useful in explaining stability but moreover in explaining the emergence of a novel set of institutions. Pagano (2011: 379–83) emphasises this complex interrelation with complementary dialectics between technology and property rights. This complementarity leads to an "organisational Nash equilibrium" where "the interactions between technology and property rights have a built-in inertia" that can prohibit development and keep the system "in a long period of stasis". Therefore, as argued by Pagano (2011: 383), "because of interlocking complementarities, we should expect the formation of new organisational species to require allopatric conditions of major external subsidies."

Consequently, it is historical specificity and path-dependency that matters for stabilizing rule-following behaviour, as was highlighted by Elinor Ostrom at several occasions: "As Ostrom (1990, 2000) insisted, they must be rules in actual or potential use in a community, and not merely rules in form" because "There is also the question of the guiding role of habit in rule-following" (Hodgson, 2015: 503). This intervention is significant for a theory of meso behaviour because it demonstrates the necessity of populating the economic space with agents carrying and sharing particular rules in heterogeneous actions. Ostrom's (2005: 135–216) attempt in assessing rules in collective action problems highlights the relevance of their underlying evolutionary processes. Her strategy to cope with the evolving diversity of different rules is to establish a generic rule-based approach (Ostrom, 2005: 181–4) working on two axes, a horizontal and a vertical one. The former focuses on the structural components, as given by position, boundary or aggregation rules (among others), and the latter on process components, such as operational, collective choice and constitutional-choice levels (Ostrom, 2005: 186–215). In a similar vein, Dopfer and Potts (2008: 6–10) discuss generic rules as cognitive, behavioural, social and technical rules on the structural axis and the order of rules on the process axis; constitutive, operational and mechanism rules.

Ostrom's (2005: 222) analysis focuses on the rules-at-use in common-pool resource regimes, Dopfer and Potts (2008) use their terminology to develop an evolutionary economic theory where knowledge is not constant, not exogenous and evolves. A further difference to Ostrom's rule-based approach deals with the structural component of object rules. In Dopfer and Potts (2008), objects such as institutions and organisations have agency but also technical artefacts,

machines or even techniques. The latter typology signifies the material turn in the social sciences as discussed recently by D'Adderio (2011) who is working with the Latourian ontology of actor-network theory (Latour, 2005). To this extent, meso behaviour organises not just on behalf of typical individual micro carriers such as households but also, strictly speaking, in coordination with social carriers such as institutions and organisations as well as object carriers such as artefacts or machines within a flat ontology.

At the core of this model we find a meso unit that consists of a generic rule and its carrier population. A generic rule represents the analytical form of an idea: "A rule is defined as the idea that organises actions and resources into operations" (Dopfer and Potts, 2008: 6). However, it is not the rule that stands in the center of attention but the carrying agent. The micro theory within this approach is elaborated by Dopfer (2004) where carriers are both rule-makers and rule followers. With this conception agents face different micro trajectories, or life-cycles with distinct behavioural patterns rendering them as active entrepreneurs and/or passive adopters. It is crucial that in such a picture of economic behaviour agents are not aggregated into representative agents anymore and behaviour is of heterogeneous nature. Dopfer and Potts (2008: 5) argue that the micro entity is neither influenced solely by internal (e.g. preferences) nor external (e.g. institutions) signals as primary sources for behavioural response.

It is rather this bimodality between internal and external signals establishing the agents as different decision makers, an argument that is very close to the already discussed notion of choice in Hanappi (2008). Therefore, the agent is not just a carrier "of rules for operations" but "the locus for originating, adopting and retaining new rules" (Dopfer and Potts, 2008: 5). A significant puzzle stone for discussing the relation between micro and meso is given by similar research on routines as developed originally by Nelson and Winter (1982: 14-19). Relevant implications for routines are considered as "pertaining to organised groups, rather than individuals", "involving the notion of procedural memory", "recurrent interaction patterns" and "involving change driven by individuals" (Lazaric, 2011: 147). The concept of routines seems to be important for meso behaviour, because they act as "generative structures and behavioural patterns at one at the same time" (Vromen, 2011: 186). And, most importantly, "Only multi-agent collectives such as groups and organisations can have routines. ... 'Routines' are reserved exclusively to denote possible properties of collectives" (ibid.). Routines retain novel rules in organisational context and stabilize a meso unit to establish behaviour on its own.

Meso behaviour depends on several micro trajectories, but originates its own trajectory that is adopted or shared by many carriers of different kind. Direct aggregation from micro to macro is rejected thereby, the relation works rather "via the emergence and self-organisation of meso populations and structures" (Dopfer and Potts, 2008: 22). Meso behaviour governs the translation between micro and macro, if and only if we speak of diversity among meso units. Ostrom and Basurto (2011: 333–7) argue that a theory of meso seems to be promising for further investigation, in context of empirical research as well as agent-based modelling. The same argument has been made by Delli Gatti et al. (2010: 119) from a macroeconomic perspective. Recent explicit attempts in this direction were implemented by Blind (2012), Wäckerle (2013) or Blind and Pyka (2014). A more generic example of generating meso behaviour is illustrated by Dopfer (2012) in terms of Schumpeter's legacy. It is conceptualized as a "meso trajectory" consisting of a structure and a process component. The former is conceived as a rule-structure (the way that we think about our economy, deal with it and categorize it). The structure is real once it is actualized via operations and this constitutes the latter, the process component of economic change.

> In combination, we get an integrated elementary unit that can serve as an instrument for the description of both structure and process of an economy. ... The idea can serve as

> structure component, the set of physical actualizations as process component. The bimodal nature of the elementary unit breaks up with the traditional micro-macro dichotomy.
>
> *(Dopfer, 2012: 145–6)*

In summary Schumpeterian meso behaviour can be sketched as a process consisting of six phases:

I Origination

Sub-phase 1: creation of novel idea, that is, invention
Sub-phase 2: search, discovery and recognition process, microscopic selection

II Adoption

Sub-phase 3: first adoption, that is, innovation, chaotic environment, bifurcation, uncertain outcome
Sub-phase 4: macroscopic adoption of "seed", selective environment, path-dependence

III Retention

Sub-phase 5: retention of adopted "seed", meta-stability of actualization process
Sub-phase 6: existing regime as breeding ground for novel potential(s), link to phase I (Dopfer, 2012: 148).

As outlined by Dopfer (2012), this kind of meso dynamics depends on social interaction in a heterogeneous population of agents and it cannot be reduced to a diffusion process of a "single valued variable, but as a process in which individuals interact with an emergent population in a self-reinforcing way" (ibid.: 149). This aspect indicates the complementarities with Veblen's concept of cumulative causation of habits of thought and signifies the potential for a common theory of meso behaviour. The ways that meso behaviour is generated are different in terms of its actualizations but in its generic nature they share common conceptions of structure and process components.

Elsner and Heinrich (2009), and Elsner (2010) take a similar point of departure as Aoki (2001) but elaborating more on the potential mechanisms leading to an emergent meso-sized population. Elsner (2010: 447) considers co-evolutionary components as essential for the emergence of a meso-sized population, that is: "(1) a complex incentive structure, (2) experienced expectations, indicative (in varying degrees) of (3) the group size, and (4) the institution as such (as both quest and outcome of the individual's effort)." In this context, the author analysed the strategic behaviour of micro agents playing a pairwise prisoner dilemma. It is suggested to employ dynamics of critical mass processes as Schelling (1978: 102–10) emphasises in terms of "tipping" phenomena. In this analytical realm, Elsner (2010) is not obliged to introduce heterogeneous agents basically, because meso appears here as a problem of size primarily, a "minimum critical mass" within a given population. However, even quite simple extensions to the game-theoretical model show how the emergence of a meso-sized interaction arena can be supported endogenously, such as "contingent trust", "memory and monitoring", "reputation chain" and "partner selection" Elsner (2010: 466–72). Elsner's (2010) conceptualization of meso follows institutionalists' arguments with regards to instrumental and life-enhancing habits of thought. These allow a pragmatist mode of collective reasoning and decision-making necessary for institutionalization. The cumulative process of meso reproduces stylized facts investigated by other evolutionary economists researching the

complexity of technological change (e.g. Arthur, 1989). Recently, Arthur (2015: 16) has acknowledged the potential of a common meso theory as developed by Dopfer and Potts (2008), and Elsner and Heinrich (2009). In these terms, I propose combining the evolutionary with the complexity foundations of meso behaviour. A candidate for such an analytical endeavour is given by the agent-based methodology as also indicated by Gräbner (2015).

Modelling meso behaviour: growing artificial economies as complex adaptive systems

Following these derived concepts, it is proposed to model the generation of meso behaviour on behalf of interactions between different economic agents in a given environment. The complexity is, therefore, not intrinsic to the agent itself. For this very reason, it is important to investigate the relations between the involved agents and how they build up systems creating agency on their own. Complex systems are hierarchical because they consist of subsystems which consist of subsystems themselves.

> By a *hierarchic system,* or hierarchy, I mean a system that is composed of interrelated subsystems, each of the latter being, in turn, hierarchic in structure until we reach some lowest level of elementary subsystem. In most systems in nature, it is somewhat arbitrary as to where we leave off the partitioning, and what subsystems we take as elementary. ... We shall want to include systems in which there is no relation of subordination among subsystems. ... For lack of a better term, I shall use hierarchy in the broader sense introduced in the previous paragraphs, to refer to all complex systems analyzable into successive sets of subsystems, and speak of "formal hierarchy" when I want to refer to the more specialized concept.
>
> *(Simon, 1962: 468)*

Simon's (1962) understanding of formal hierarchy—as "partitioning in conjunction with the relations that hold among its parts"—is essential for any concept of meso behaviour because it assumes a flat ontology of components, subsystems and systems where all the objects and subjects stand "next to each other" without any assumed authoritative subordination. From this point of departure, Simon (1962: 473) underpins the topic of complexity with evolutionary arguments and shows that complex systems evolve on behalf of simple systems and "much more rapidly if there are stable intermediate forms than if there are not." In economics, such stable intermediate forms are meso units. Hierarchy leads us to the notion of decomposability, in particular that of "nearly decomposable systems" (ibid.). The latter terminology refers to the interactions among and between subsystems. Hierarchy in near-decomposable systems informs us on the frequency of interactions, thus frequency increases by magnitude of one or two when we go one step downward in the formal hierarchy of a system and vice versa. This conclusion seems intuitive when we consider economic systems and their hierarchies. The frequency of interactions between households (micro) is much higher than that of interactions between regions, organisations, industries or political economic networks (meso) or of states or monetary unions (macro). Nearly decomposable systems share the characteristics of weak but not negligible interactions among subsystems, as also argued by Csermely (2009) in the context of "nestedness" and "weak links". The most noteworthy implications for meso behaviour and its analytical generation deal with the time horizon.

> (a) in a near-decomposable system, the short-run behaviour of each of the component subsystems is approximately independent of the short-run behaviour of other

> components; (b) in the long-run, behaviour of any one of the components depends in only an aggregate way on the behaviour of the other components.
>
> *(Simon, 1962: 474)*

Meso behaviour involves autonomous action and the interaction of meso units informs on the long-run macro behaviour. Veblen and Schumpeter considered different time horizons in their work and have always emphasised the sociohistorical context of development. Concerning the Schumpeterian case, the emergence and stabilization of a meso unit is effected by its short-run behaviour, which strongly depends on the interactions of the entrepreneur, its financier and its adopters. This type of meso behaviour is connected to Schumpeter Mark I (Schumpeter, 1934). Otherwise, in the long-run the meso behaviour depends in an aggregate way on the behaviour of other meso units within the whole economy, as considered in Schumpeter Mark II (Schumpeter, 1942: 79–82).

The processes of widening (Mark I) and deepening (Mark II) meso behaviour relate to Simon's (1962: 476–477) remarks on the "width of hierarchic span"; a hierarchic span is thereby understood as an indicator for the modularity of such nearly decomposable systems (Callebaut, 2005). According to Simon (2005) these systems are more likely to adapt in local niches. Formal hierarchical modularization makes systems more flexible to adapt and more robust to changes in a given environment. Generating meso behaviour depends strongly on the modularity of the modelled system. To begin with, it is proposed to assume rather simple satisficing heuristics (Simon, 1987; March, 1991; Winter, 2000) for the behaviour of micro agents rather than optimizing decision rules. This conception of micro agents is also highlighted by Beinhocker (2007: 118), who follows a quite similar route in combining evolutionary and complexity foundations for analysing economic behaviour on different scales.

Beinhocker (2007: 293) addresses the notion of economic evolution as algorithmic and synthetic where "instructions bind Physical Technologies and Social Technologies together into modules under a strategy." Satisficing micro behaviour enforces agents to collaborate and create but also contradict nested modules or meso units. Modelling such agent properties and the corresponding initialization of their systemic environment is necessary to develop a complex adaptive system. It is suggested to follow a computational approach that, moreover, allows the generation of meso behaviour in formal hierarchical terms. In particular, I want to emphasise prospects of the bottom-up or agent-based approach in computational economics (see Velupillai et al. (2011) for an overview of different approaches in computable economics).

As shown in Table 12.1, the bottom-up approach in computational economics differs substantially from traditional modelling tools. Characteristics such as the process-oriented design, as well as the possibility to model adaptive agents, feature in synergistic terms the systemic development of structure and process components of meso behaviour. Of course, algorithms represent artificial rules and stand only as proxies for more complex behavioural patterns, as discussed previously. Nevertheless, the modelling architecture focuses on space and time contextualization of agents and allows, for example, routinisation. What is the role of the computer in this respect? Holland (1992) summarizes quite illustratively:

> For example, the equation-based methods that work well for airplanes have a much more limited scope for economies. ... Despite the disparities and the difficulties, we are entering a new era in our ability to understand and foster such systems. The grounds for optimism come from two recent advances. First, scientists have begun to extract a common kernel from these systems: each of the systems involves a similar "evolving structure". ... The second relevant advance is the new era in computation ... This advance will allow experts who are not computer savvy to "flight-test" models of

Table 12.1 Modelling potential of the bottom-up approach

Traditional tools	*Agent-based objects*
Precise	Flexible
Little process	Process oriented
Timeless	Timely
Optimizing	Adaptive
Static	Dynamic
1,2, or ∞ agents	1,2, . . . , N agents
Vacuous	Spacey/networked
Homogeneous	Heterogeneous

Source: Miller and Page (2007: 79).

> particular complex adaptive systems. For example, a policy maker can directly examine a model for its "reality", without knowing the underlying code.
>
> *(Holland, 1992: 17)*

The first point raised by John Holland refers to the potential of the computational approach to generate meso behaviour that is dependent on evolving/modular structure. The second point is not of lower importance—quite the opposite—it highlights the didactic power of simulations in exploring complex adaptive systems and their potential path-dependent developments. Simulation (Gilbert and Troitzsch 2005: 5) particularly allows the investigation of emergence, "path-dependence, nonergodicity and cumulativity in processes of change" (Elsner et al., 2015: 10–11). Nevertheless not every simulation technique is appropriate in this regard. Figure 12.1 illustrates the development of simulation techniques and arranges them in two broad categories, where the grey-shaded area contains equation-based models and the white area contains either object, event or agent-based models. Among these techniques, we find cellular automata and agent-based models that are suitable to simulate the aforementioned dynamics. Agent-based models fall under the category of multi-agent models with communication between multiple agents as well as a sufficient degree of complexity concerning the individual heterogeneous agent. A typical example for such a multi-agent model is given by the "Sugarscape" model developed by Epstein and Axtell (1996: 21–53). The model consists of resources as well as social rules and heterogeneous individual metabolisms. In its most basic form "Sugarscape" already implies meso behaviour, since the distribution of wealth develops endogenously by influencing the "cultural" behaviour of individual agents thereafter. This case becomes even more evident with particular extensions allowing the emergence of trade and credit networks (Epstein and Axtell, 1996: 94–137).

Computational simulation suits the social sciences better than mathematics. A big part of this advantage is given by the usage of programming languages that are more expressive and less abstract than mathematical techniques. Programs are modular and deal more easily with "processes without a well-defined order of actions" (Gilbert and Troitzsch, 2005: 7). Elsewhere, Gilbert (2008) highlights the power of programming languages in designing artificial agents for proper use in agent-based models. The most important characteristics for agents and their micro trajectories in such models are given below:

- Autonomy – There is no global controller dictating what an agent does; it does whatever it is programmed to do in its current situation.

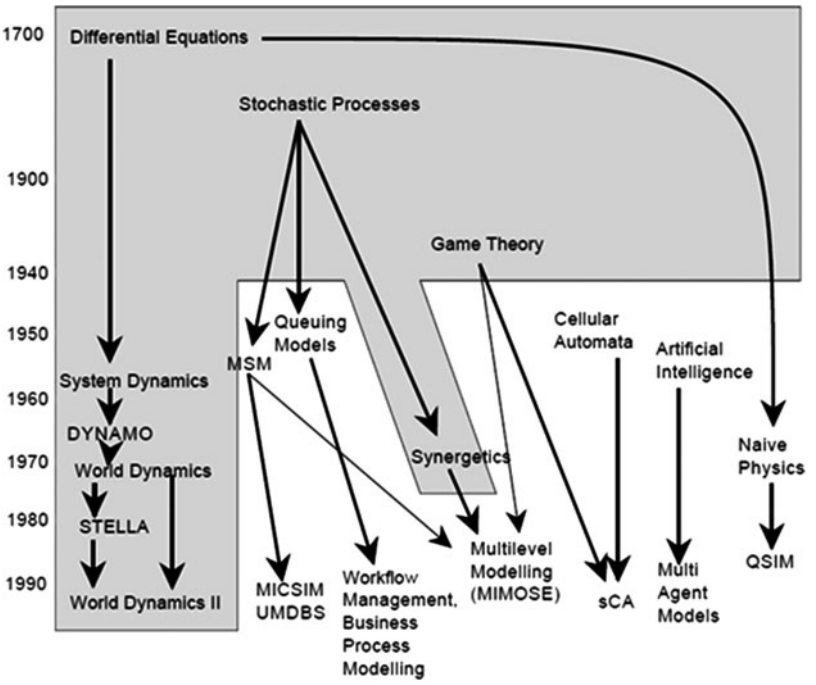

Figure 12.1 Development of different simulation techniques in the social sciences

Source: Gilbert and Troitzsch (2005: 7).

- Social ability – It is able to interact with other agents.
- Reactivity – It is able to react appropriately to stimuli coming from its environment.
- Proactivity – It has a goal or goals that it pursues on its own initiative.
- Perception – They can perceive their environment, possibly including the presence of other agents in their vicinity. In programming terms, this means that agents have some means of determining what objects and agents are located in their neighbourhood.
- Performance – They have a set of behaviours that they are capable of performing. Often, these include the following:
    - Motion – They can move within a space (environment).
    - Communication – They can send messages to and receive messages from other agents.
    - Action – They can interact with the environment, e.g. "picking up food".
- Memory – They have a memory, which records their perceptions of their previous states and actions.
- Policy – They have a set of rules, heuristics, or strategies that determines, given their present situation and their history, what behaviours they will now carry out (Gilbert, 2008: 21).

These distinctive properties stand in the foreground when it comes to generating meso behaviour, because they enhance the ontological correspondence between computational agents and

real-world actors. The benefit of this approach relates to the development of modularity by growing the system from the bottom up, a principle that is considered as generative.

> Situate an initial population of autonomous heterogeneous agents in a relevant spatial environment; allow them to interact according to local rules, and thereby generate – or "grow" – the macroscopic regularity from the bottom-up.
>
> *(Epstein, 2006: 7)*

To grow and generate a system, it is necessary to change the language structure from mathematical equations to computational algorithms and programs. Social interaction is too complex to represent it in comprehensive and recognizable recursive equation systems, here the agent-based methodology is more intelligible and accessible to us. Meso behaviour is then generated via growing artificial societies from the bottom up, modelled via heterogeneous agents that imitate, innovate, adapt, adopt or even resist. An emerging meso unit differs substantially from other meso units due to its distinct rule-structure. To this extent it is worthwhile to differentiate between heterogeneity and diversity (D'Ippoliti, 2011), where the former is associated with micro agents and the latter with meso units. Meso behaviour differs from group- or system-based behaviour because it underlies explicitly an evolutionary process of origination, adoption and retention, with regards to distinctive shared rules transforming its structure and process components.

In the literature, we find several examples of agent-based generated meso behaviour, which mostly deal with aspects of imitation, adaptation and innovation. I highlight Elsner and Heinrich (2011) or Wäckerle et al. (2014) in relation to institutional economics, Janssen and Ostrom (2006) or Safarzynska (2013) in relation to ecological economics, Gilbert et al. (2001) in relation to innovation economics and Fagiolo et al. (2007) in relation to social policy. Dosi et al. (2010) present an agent-based macroeconomic model with a distinctive capital goods market and model the development of Schumpeterian innovative behaviour in complexes that we can consider as meso units. Ciarli et al. (2010) deliver an agent-based macroeconomic model that features both consumption and production on the micro level, as well as income distribution, and investigate structural change and growth thereby. Cincotti et al. (2010) provide a similar framework with regards to scope and scale but highlight more the Minskian financial aspects of credit-driven investment and systemic risk. Rengs and Wäckerle (2014) have particularly addressed the notion of Veblenian institutional consumption dynamics and its effects on firm organisation in a political economy with social classes. Delli Gatti et al. (2011) provide otherwise a very detailed instruction into macroeconomics from the bottom up. Together, this type of research develops a new kind of agent-based meso-founded macroeconomics by focusing on the progressive behavioural elements of development.

Concluding remarks

In this chapter I have highlighted why a theory of meso behaviour is important and why it is distinct from the homo oeconomicus model. I have motivated this endeavour on behalf of a brief tour through the history of economic thought, in particular through the work of Veblen and Schumpeter. Both of these seminal scholars have highlighted non-aggregate aspects of a dynamic, systemic and to some degree evolutionary economics. At the core of their economic models, I locate meso behaviour as the agency and adaptive/creative response of a meso unit that emerges on behalf of coordination and organisation of individual heterogeneous economic agents in social systems. I have emphasised the instrumental, creative and life-affirming proclivities of agents in

the industrial society that enforce generative micro behaviour for meso, as found in the prototypes of the Veblenian engineer or the Schumpeterian entrepreneur. Analytical categories have been introduced to model social interaction, such as origination, imitation, innovation, adaptation, adoption and resistance. The framework of mesoeconomics is discussed in detail, highlighting formal preliminaries for generating meso behaviour. Thereby, a meso unit is on the one hand understood as a generic rule and its carrier population that goes through different stages of behaviour during its trajectory and interacts with other micro, meso or macro entities. Meso behaviour is thereby understood in a Schumpeterian understanding of innovation. On the other hand, meso refers to a platform size and interaction arena where individual agents coordinate to overcome social-dilemma type problems. This conception of meso relates to institutional economics and the pragmatist approach to collective action problems. To generate meso behaviour, it is necessary to think about agents in a Simonian understanding of satisficing behaviour. Such heterogeneous agents are furthermore part of a modular structure of systems, where complex systems adapt more rapidly if there are stable and intermediate forms in between. This architecture of complexity demands computational and algorithmic techniques for appropriate models and simulations. I have summarized some central properties of agents and systemic environments in such models, and have indicated how meso behaviour can be generated from the bottom up in such artificial economies.

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