Micro to Macro Evolutionary Modeling: On the Economics of Self Organization of Dynamic Markets by Ignorant Actors

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Abstract The Micro to Macro model MOSES, for Model of the Swedish Economic System, is presented as a synthesis of Austrian/Schumpeterian and Swedish/Stockholm school economics. That connection unfortunately failed to be achieved at the time, as Swedish economists abandoned their ambition to take their Ex ante Ex post analysis down to the micro level for neoclassical static equilibrium economics, and therefore also failed to establish a Swedish platform for evolutionary economics. I argue that evolutionary models have to be micro based to make sense as driven by entrepreneurial competition and selection among autonomous market agents, be economy wide as an economic system, and should feature *endogenous evolutions of firm populations*, a complex dynamic that makes the model unsolvable for a market clearing equilibrium. The initial state dependency of such highly non linear selection models furthermore makes them unavoidably empirical. Since empirical models are always related to a case economy, the Moses model has been drawn up within the general theoretical framework of what I call an *Experimentally Organized Economy* (EOE), and applied to the Swedish economy. The estimation/calibration problems associated with such models are addressed, and the empirical credibility of the *surprise economics* that they generate discussed.

Entrepreneurial entry drives competition and growth of the Micro to Macro model economy through a Schumpeterian type Creative Destruction process, that however also endogenously both raises the rate of exit, changes the population of actors, and lowers (because of the consequent structural change) the reliability of market price signaling as predictors of future prices. Simulation experiments suggest that *an optimal growth maximizing rate of firm turnover exits*.

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When MOSES is deprived of its micro based evolutionary features and firms are aggregated to sectors a traditional computable general equilibrium (CGE) sector model is shown to emerge as a special case. The static equilibrium properties of that model, however, are incompatible with the operating domain of the dynamic MOSES model, and *a neoclassical capital market equilibrium comes out as an undesirable state to aim policies for*. I conclude by demonstrating that the Wicksellian Cumulative Process can be nicely fitted into the Micro to Macro model.

1 Problem Formulation Against the Background of Economic Doctrines

The Micro to Macro modeling project was empirical from the start. The ambition was to design an economy wide dynamic model economy populated by "live" actors, all being always, but differently ignorant about circumstances that might fundamentally change their ways of life, or even threaten their existence, and on a foundation of observable and relevant "facts". This model design still turned out to have a recognizable place in the familiar history of economic doctrines. So I begin from there.

Economic actors make up ex ante plans, or set up business experiments, that more or less fail to be realized ex post, as conceived. Thus economic mistakes are an unavoidable determining element in the evolution of an economy as a complex economic system of behaving agents that interact and compete in markets. Endogenous entrepreneurial competition forces the "creation of novelty", to use a term from the evolutionary economics literature, or new innovative "ideas"[1] to be commercialized, and an irreversible selection on the population of actors, favoring viable actors, and forcing others to exit. This endogenous evolution of a complex population of heterogeneous actors makes the economy highly non transparent from any observation point, gross ignorance of circumstances (that may be critical for survival) a pervasive characteristic, and unpredictability and the making of (non random) economic decision mistakes a normal occurrence at individual as well as central policy levels. *This all occurs at the intersection of Austrian/Schumpeterian and Stockholm School economics*. A model of an economic system that fails to embody those characteristics, such is my argument, will fail to convey a credible understanding of the behavior of a real economy. The analyst relying on the wrong model might however be unaware of its empirical shortcomings, which raises the problem of empirical credibility.

A key, and controversial element in modeling economic evolution concerns the endogeneity of innovation and entrepreneurial competition. Innovation means

[1] Just for information, in neoclassical growth literature you find R&D based "innovation" or "Ideas production functions" [see i.e. Jones and Williams (1998)] that, as I will argue below, come very close to the idea of an "innovation system", the latter often claimed to be evolutionary.

venturing into the unknown, and therefore by definition defies explicit explanation and modeling of ex post outcomes. This, referring to Witt (2002) has cast doubt on the proposition that Schumpeter was an evolutionary economist. It all, however, depends on what one means by evolutionary economics, and the Micro to Macro model Moses turns out to be an ideal instrument to discuss that question.[2] The trick is to endogenize the conditions that are necessary for *the creation of novelty in the form of creating and selecting improved technology in terms of the characterization of what market agents* (firms) do in the model. As a consequence modeling the evolution of an economic system as moved by entrepreneurial competition, to make sense, has to begin at the micro "behavioral" level, and be explicit about how that selection of agents occurs in the markets of the model.

The characteristics of economic behavior so emphasized were the characteristics of two, of the three competing schools of economics that were developed during the late part of the nineteenth and the early twentieth centuries; the *Austrian*, the *Swedish* (Stockholm) and the *French,* with their respective founding fathers*;* Menger/Schumpeter, Wicksell and Walras. The winner at the time, the Walrasian, or neoclassical model, soon eclipsed the other two. The Walrasian model, however, lacked the critical characteristics of a dynamic evolutionary economy, and is currently, more than a century later, subject to competitive pressure from Austrian/Schumpeterian related economists for its failure to recognize ignorance, its incompatibility with a meaningfully defined entrepreneur, and its lack of relevant dynamic content.

While Schumpeter verbally gave his exogenous innovator/entrepreneur a role in economic development, the concept of Ex ante and Ex post of the Stockholm school economists, and their emphasis of expectations and plans that constantly fail to be realized, defined not only an opening for modeling the role of meaningfully defined entrepreneurship in a macro economy, but also for modeling the endogenous economic evolution of a complex economic system through "Darwinian" selection (Winter 1964), and an economic system set in unavoidable perpetual evolution by competition. The Stockholm School economists, however, missed that opportunity by refusing to take their analysis down to the micro level, arguing that it would not add to our understanding of economics. The Austrian economists never really attempted the formidable task of explicitly modeling all interacting economic agents within a coherent dynamic market systems framework. In fact, Carl Menger was against mathematical modeling of the economy, which I am not, and was frustrated to learn that his best students (Eugene von Böhm–Bawerk and Friedrich von Wieser) had fallen into the trap of easy Walrasian modeling, which I will not.

The followers of Walrasian economics soon eclipsed the two alternative schools by their ingenious design of transparency, easy teachability and convenient

[2] To understand that, however, requires some technical understanding of the Moses model economy. The literature reference list therefore becomes quite long to make it possible for the interested reader to access the details of the model he needs. Some technicalities that clarify the evolutionary nature of the model furthermore have been moved to the Supplement.

mathematical representation. Austrian and Swedish school economics therefore failed to connect. Since Swedish school economics had an element of Keynesian economics, or even predated Keynes in several respects (Schumpeter 1954: 1173f), the world got the general (static) equilibrium (GE) model, on the one hand, which that still fails to recognize a meaningfully defined entrepreneur and (non random) economic mistakes, and, on the other, the Keynesian policy model that confers more theoretical leverage to politicians interfering ambitiously with the economy, than the understanding they (and their economic advisers) have, and that rational voters should trust that they have. As a consequence both the Austrians and the Swedes of the original descent shut up for half a century.

This "Grand System of Economic", writes George Shackle (1967: 4f) on the general equilibrium model, was complete in essentials" before the end of the nineteenth century, and "in its arresting beauty and completeness this theory seemed to need no corroborative evidence from observation". Alfred Marshall was the academic authority on the Walrasian model at the time, and was highly critical of its empirical shortcomings. During the early post WWII years Walrasian minded static equilibrium economists nevertheless managed to disconnect a promising merge of the Austrian/Schumpeterian and Stockholm Schools, and for decades more or less block the development of evolutionary economics.

On the neo Walrasian, or general equilibrium (GE) model, Hansen and Heckman (1996) write that it is "practically devoid of economic content, close to trivially true, and therefore hard to reject empirically". It is "vacuous" Clower et al. (1998) adds. How could such an empirically empty model gain such dominance in economic teaching and research?

Hansen and Heckman (1996: 101) continue to deplore the lack of attention paid in literature to the transition from Micro to Macro. A redirection of micro empirical research towards providing inputs into well defined GE models would move the economics discussion towards the intellectually (more) important task of clarifying how micro estimates can be used to illuminate well-posed macro economic questions. The GE model, despite its empirical emptiness, might then be used as a synthesizing device to aggregate from Micro to Macro, Hansen and Heckman (1996) add, or as I prefer to express it; as a neutral economic measurement instrument that imposes a minimum of prior content on the data. "A widely accepted empirical counterpart to the general equilibrium theory" however still "remains to be developed", they continue, or a model that can be rejected by data, if wrong.

I will present such a desirable counterpart to the general equilibrium model, which however still remains to be widely accepted; the Swedish Micro (firm) to Macro model MOSES, that celebrated its 40th anniversary in 2014. I will demonstrate its original conception as what was later called an evolutionary model, and demonstrate how those properties derive from the merge of Austrian Schumpeterian and Swedish Stockholm, school economics.

After this background of the history of economic doctrines, the theory of an *Experimentally Organized Economy (EOE)*, and its model approximation, the *Micro to Macro model MOSES,* will be presented in the next Sect. 2 as evolutionary, and distinctly different from the standard neoclassical model, and its empirical application the Computable General Equilibrium (CGE) model in that economic development occurs through explicitly modeled market intermediated selection among autonomously behaving agents. I then continue in Sect. 3 to present the Micro to Macro model, the mathematical code of which will be seen to feature such non linear complexity as to pose a number of difficult but interesting estimation/calibration problems to be addressed in Sect. 4. While the a priori specifications of the model are empirically reasonable and well researched, they give rise to unusual economic systems behavior that is absent in the received economic models. Such *surprise economics* raises a credibility problem that is addressed in Sect. 5. Finally, and quite in keeping with the doctrinary origin of this whole modeling venture, I derive a stylized version of the Wicksellian cumulative process, the ultimate variant of Stockholm School economics, from the Micro to Macro model in Sect. 6. (For practical reasons most of the technical and philosophical discussion of what distinguishes the evolutionary Micro to macro model from received and familiar equilibrium theory has been moved to the Supplement).

2 Life in an Experimentally Organized Economy (EOE)

The system of general postulates and building blocks of an Experimentally Organized Economy (EOE), to be verbally presented here, serves as a theoretical frame for its approximation, the quantified Micro to Macro model empirically set up for the Swedish economy. The theoretical design of an EOE has been used to interprete and generalize from the simulation experiments to other economies.

For reasons to be briefly explained below, but being already presented in Eliasson (1991a, 1992, 2005b, 2009) the Micro to Macro model should therefore be seen as a narrowed down model version of a more general theory of an *Experimentally Organized Economy (EOE),* that frames the empirically implemented model. Four postulates govern life in an EOE;

1. The *Särimner proposition*, that defines the business opportunities space[3] of the theoretical Micro to Macro economy. This proposition establishes universal and everlasting ignorance as the normal state of affairs among market agents, and economic mistakes as a normal and determining element in economic evolution
2. *Schumpeterian Creative Destruction*, or economic growth through competitive selection
3. *Competence bloc theory* that governs the dynamic or Schumpeterian evolutionary efficiency of that selection
4. *Endogenous entrepreneurial entry* that moves competition and keeps the creative destruction machinery perpetually activated.

[3]Or the state space of the corresponding mathematical model.

The ambition of the Micro to Macro modeling project has been to be up to those general guiding theoretical principles.

2.1 The Business Opportunities Space and the Särimner Proposition

The state of information in, and the size and complexity of the space of opportunities which economic agents explore are the fundamental postulates of economics (Eliasson 2005a, 2009). Fundamental ignorance among agents of an economy was one foundation of Austrian/Menger economics. Since agents explore the opportunities space, and learn about its content, it becomes necessary to have something to say of what *prevents* agents from learning all about the interior of that opportunities space such that the model economy cannot reach the state of full information, taken for a fact in traditional Walrasian economics. That prevention is provided by the Särimner[4] postulate, which simply states that we are getting increasingly ignorant about all that can be learnt about, or the economic opportunities space, because *the rate of expansion of that space, driven by its exploration and learning, is faster than the rate of learning of its content*. Let us for the time being leave that proposition of the relative rates of learning and expansion as an empirical proposition that can be tested, and proceed on the assumption that so is the case, and that the Särimner proposition will keep all actors in the economy in perpetual ignorance, and constant unrest and anxiety to be overrun by competition, forcing them to counteract by innovation, or be competed out of business. The point made is that entrepreneurial competition in a viable EOE forces innovative performance on the agents in the market. There is no need to assume anything about entrepreneurial spirit or innate entrepreneurial capabilities on the part of agents. If they don't do anything, or don't know how to do it, they perish. This dynamic keeps the economic system diverse and viable, and from collapsing into a state of full information. As a consequence systematic wedges between ex ante plans and ex post outcomes are created that not only provide a bridge between Austrian and Stockholm School economics, but also introduce the economic mistakes of Menger and von Hayek, and mistake prone selection as the normal vehicle for economic progress. This is also the basic economics behind the growth promoting Schumpeterian Creative Destruction of the Micro to Macro model as stylized in Table 1, which makes up a credible story of endogenous growth through competition driven selection.

[4]From the pig in the Viking sagas that was eaten for supper, but came back again the next morning to be eaten again, and so on. The difference in the theory of the EOE is that the opportunities space grows from being explored through learning. The Särimner proposition was first presented as one of three information paradoxes in Eliasson (1987a: 29, 1990b: 46ff).

Table 1 The four mechanisms of Schumpeterian creative destruction and economic growth—going from micro to macro

1.	Innovative entry *enforces* (through competition)
2.	Reorganization
3.	Rationalization or
4.	Exit (shut down and business death)

Source: Eliasson (1996a: 45)

2.2 *Schumpeterian Creative Destruction: A Graphic Salter Curve Presentation*

The population of firms in a market can be ranked according to a number of criteria and statistically presented in Salter curve graphics. Figure 1a ranks the entire manufacturing firm population of the Micro to Macro model to be presented below by labor productivity and wage costs 1983 and 1997. Figure 1b shows the corresponding distribution (for 1983 only) of rates of return over the interest rate ($R - i = \varepsilon$),[5] all data coming from the MOSES Data Base (Albrecht et al. 1992).

[5]A large number of persons have been involved in the Moses project from its initiation by IBM Sweden in 1974, without whom the project would have been stranded along the way. That Axel Iveroth, then President of the Federation of Swedish Industries, not only allowed the project to be located at my Department of Economic Policy, but acively encouraged it, was of course critical. Ola Virin at my department was instrumental in setting up the Planning Survey to firms, which not only served the model with firm data, but also became increasingly useful in the business forecasting activities of the Federation. The computer programming skills of Mats Heiman and Gösta Olavi at IBM Sweden have to be specially mentioned. Thomas Lindberg, Lars Arosenius, Ingemar Hedenklint and Ulf Berg, also at IBM Sweden were not only extremely helpful in setting the project up, but also actively interested in its progress. Their constant interested attention definitely contributed to the model being up and running on time. Ragnar Bentzel of Uppsala University, once my thesis adviser, was constantly acvailable for discussing the project during its early formative years.

Jim Albrecht, then at Columbia University, joined the project when it had moved with me to the IUI, as did later Ken Hanson from USC. Bot were instrumental in broadeing the model specification, and keeping it running, as it constantly hit the capacity ceiling of even large mainframe computers. Thanks also go to Fredrik Bergholm, Tomas Lindberg, Jörgen Nilson and many others at IUI without whom we would never have got the large database work in order. Bo Carlsson's early economy wide, dynamic cost benefit calculation on the Moses model of the Swedish industrial support program during the 1970s and 1980s, and his studies on how technical changes at the micro levels worked themselves through the model economy generating structural change, in many respects pioneered new analytical methods, but also helped promote the model in the policy community.

With Erol Taymaź arrival at the IUI from CWRU in Cleveland in the late 1980s modelling took a great leap forward, and thanks to the continued cooperation with Erol, now at Middle East Technical University (METU) in Ankara, and with Gerard Ballot at Paris II, Pantheon, the Moses model is still progressing according to some tacitly udnerstood general design. Without the strict

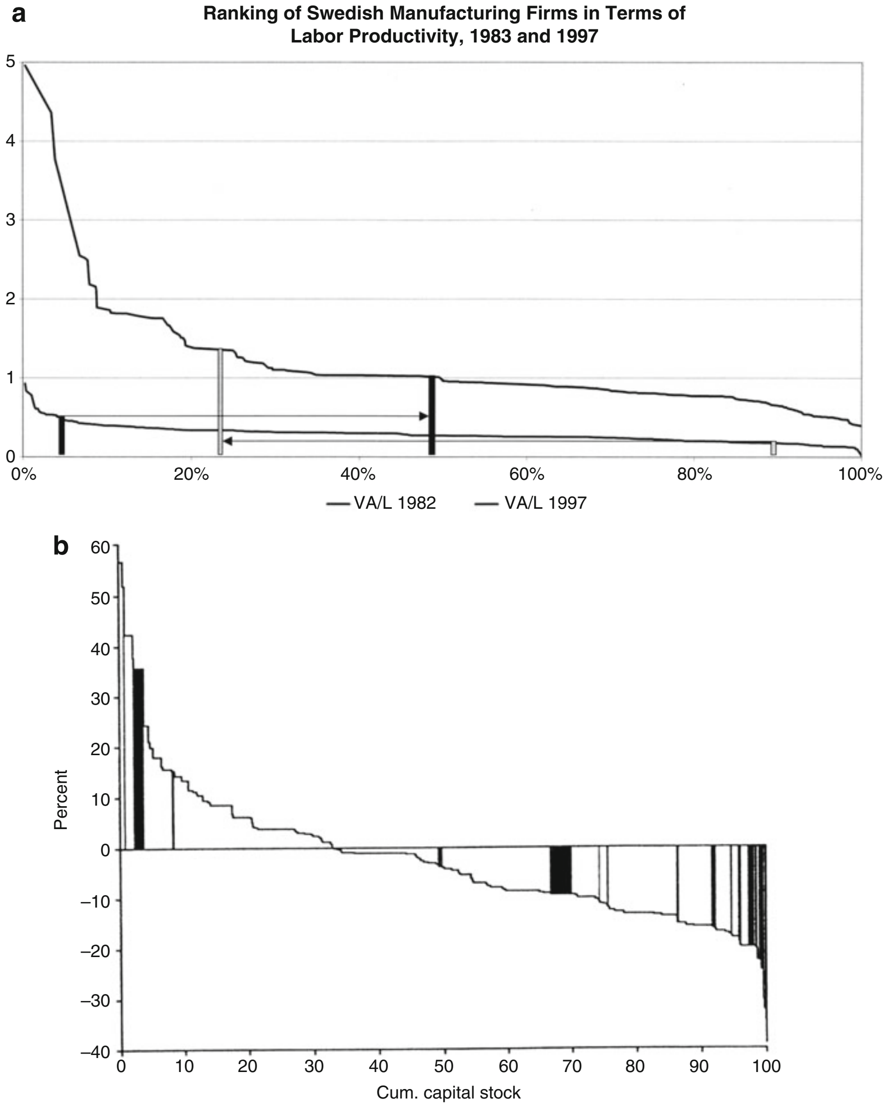

Fig. 1 (**a**) Labor productivity Salter distributions 1982 och 1997. *Source*: Moses Data Base (1992). (**b**) Salter rate of return over interest rate (= ε) distributions. *Source*: Taymaz (1992a: 158)

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protocol of econometric method voiced by Anders Klevmarken from the beginning of the Moses project, we most certainly would not have taken Moses calibration as seriously as we now have.

Thanks also go to an anonymous referee who wondered whether Moses really was evolutionary, and if so urged me to clarify how exactly the evolutionary nature of Moses distinguishes it from the received neoclassical, or the Keyenes-Leotief sector models. That should have been achieved with the Supplement in Sect. 8.

To the left in Fig. 1a we have the most productive firms with the largest profit margins (difference between productivity and wage cost curves), provided they are not particularly capital intensive, in which case they will be ranked lower in Fig. 1b. Far down to the right on both curves are the low productivity and loss making firms. The columns show two Swedish firms, the width measuring their size as a share of total value added in Swedish manufacturing, one firm (solid column) having lost in ranking between 1983 and 1997, while the other has improved its ranking.

If a firm is generally ranked below another firm it is challenged by that firm to improve its performance through innovation, or be competed down to the right along the Salter curve. For the same reason the superior firm is challenged both by superior firms to its left, and by the inferior firms to its right, the latter trying to leap frog their positions through innovation to avoid the competition, and so on over the entire range of businesses.

And this is not enough. In the wings potential entrepreneurs lurk, waiting for opportunities to enter the market. The general characteristics of those firms is that on average they are inferior to the incumbents, but their performance spread is very wide, and being entrepreneurs they are optimistic about their opportunities to succeed (Why would they otherwise try?), so whenever possible they enter the market, challenging a whole range of incumbents.

As higher productivity firms survive, and improve their productivity performance, and lower productivity firms shrink or exit (in Table 1) the Salter productivity distributions shift outwards, and the macro economy grows.

Technology is, however, not sufficient to explain economic growth, but necessary to frame the growth potential of the economic system as embodied in the Särimner proposition. *New technology has to be commercialized to result in economic growth, and the commercialization process is far more resource demanding than innovative technology development itself, not least because of all the business selection mistakes made along the way*. Given the opportunities space and the competition forcing business actors to explore it, there is a need to explain the dynamic efficiency of that exploration, of identifying the winning opportunities and to carry them on to industrial scale production and distribution that together make up the *commercialization process*. Competence bloc theory does that job in an EOE (Eliasson and Eliasson 1996, 2009). A competence bloc lists (in Table 2) the minimum number of actors needed to create, identify, capture and carry winning projects on to industrial scale production and distribution.

2.3 Competence Bloc Theory Determines Dynamic Efficiency of Project Selection

The competent customer (Item 1 in Table 2) occupies the top position in the selection hierarchy. *In the long run no better products will be developed and*

Table 2 Actors in the competence bloc

1.	Competent and active *customers*
	Technology supply
2.	*Innovators* who integrate technologies in new ways
	Commercializtion of technology
3.	*Entrepreneurs* who identify profitable innovations
4.	*Competent venture capitalists* who recognize and finance the entrepreneurs
5.	*Exit and private equity markets* that facilitate ownership change
6.	*Industrialists* who take successful innovations to industrial scale production

Source: Eliasson and Eliasson (1996)

manufactured than there are customers who understand the products, and are willing to pay. All other downstream actors in the competence bloc have to pay attention to these demands of the customers.

We have the *innovators* (Item 2) that are governed by visions of technologically feasible innovations with also an eye to the demands of the customer. The innovators create the technology supplies in the markets for innovation. From there on selection in the commercialization process begins with the *entrepreneurs* (Item 3) who select what they ex ante consider profitable innovations. Entrepreneurs, however, rarely have sufficient financial resources of their own to carry their selected projects on, and therefore have to fall back on industrially competent *venture capitalists* (Item 4). Access to industrially competent venture capitalists is critical for the efficiency of project selection. Industrially competent venture capitalists are a rare species. When incompetent they charge too much for participating in projects, or dare not participate in winning projects they don't understand (Eliasson 2003b, 2005b: Chap. IV).

When the entrepreneur and the venture capitalist have developed the project further, tested its economic viability and made it ready for the market it might be turned over to the *private equity market* populated by industrially less competent, but financially more resourceful actors (Item 5). The project should now have been cleared ("branded") as a winner that financial market actors can fairly "safely" invest in (Eliasson and Eliasson 2005: 224f).

Finally, if a winner has been discovered, an entirely new competence clicks in, when the *industrialist* (Item 6) takes the project on to industrial scale production and distribution.

The *actors of the competence bloc are functionally defined*. In practice the functions, however, often mix within one empirically defined actor. The innovator may also be an entrepreneur, the entrepreneur may also be the venture capitalist, and quite often a large firm internalizes almost an entire competence bloc.

Normally the range of technologically defined innovation supplies is far wider than the competence range of *experienced based commercializers*. Since there will therefore always be more technical business opportunities than there are competent actors to identify, capture and commercialize them, a *positive failure rate can be demonstrated to always exist* (Eliasson 2005b: 40ff). Hence more or less mistaken choices abound in a progressing economy, which makes the commercialization phase in the competence bloc the by far most resource using one because of mistaken selections.

Commercialization can occur within large firms that internalize entire competence blocs, or over markets. In that sense competence bloc theory provides a dynamic version of Coase's theory of the firm (Eliasson and Eliasson 2005). Internalization by definition narrows the range of competencies and threatens the firm by bad selection efficiency. [IBM, for instance, internalized almost an entire competence bloc in the 1980s, and entered a crisis that almost wrecked the company during the last years of the decade (Eliasson 1996a: 183ff)]. External commercialization is more costly, but offers a broader range of evaluation competence. Provided the external diversified commercializing markets are in place, the risk of losing winners is minimized.

V*ertical completeness* is necessary to prevent (winning) projects from getting stuck along the commercialization sequence. A broad range of diverse competences, furthermore, is needed at each functional category of the selection range (*horizontal diversity*) to make sure that maximum competence is applied to each selection, and that each project is understood by the resource providers. *A vertically complete and horizontally differentiated competence bloc therefore defines an attractor and a spillover source characterized by intense entrepreneurial competition that drives creative destruction* (in Table 1), and makes sure that only winners survive and can access local resources. The potential winner entrepreneur can now continue to look for resources (financing) being confident that a resource provider will soon understand his project and support it at reasonable terms. If a winner, the probability that s/he will obtain the needed resources is maximized. Since belief in one's idea is the characteristic of entrepreneurial spirit, the more lively entrepreneurial supply, the faster growth, but also the larger the exit rate of mistaken business ventures, and the faster the turnover of firms (entries and exits in Table 1). Endogenous growth now occurs.

While the competence bloc facilitates the establishment and development of winning projects into successful businesses, differentiated markets for specialized subcontractors form a platform for selection of promising growth candidates. But such markets in turn have a history of evolution to begin with, that has the same explanation of experimental innovative entry. *To study the evolution of a complete economic system the initial state of the economy therefore has to be empirically precisely established.*

2.4 Allocative Efficiency in the EOE

Allocative efficiency in the evolutionary EOE economy will have to be something entirely different from the market clearing definition of the static GE model. We are now talking Schumpeterian efficiency in terms of a viable selection of winning projects or firms, or (Eliasson and Eliasson 2005) minimizing the economic loss to society (in the form of lost output) from keeping losing projects too long in production (Error Type I), and from losing winners (Error Type II), or minimizing the economic losses from Errors Type I & II. Error Type I can then be interpreted as being mostly made up of static inefficiencies, while Error Type II, or the costs to society of losing winners, is not even definable in the GE model. The first point to be made of the above efficiency definition is that by pushing policies to eliminate losers of type I too hard, the risk of rejecting winners is raised. Dynamic Schumpeterian evolutionary selection efficiency therefore means that some, perhaps even *significant slack, or static inefficiency* (Error Type I) *has to be allowed for to minimize the loss of the far more valuable winners*. It is however perfectly possible to simulate an approximate Min (Error type I&II) combination through repeated simulation experiments on the Micro to Macro model. The simulations in Eliasson (1991a), attempting to police the economy on to a zero Error Type I static equilibrium (reported on in Sect. 5) illustrates how that can be done.

In practical policy reality, however, the advice of the Micro to Macro model will rather be that achieving maximum Schumpeterian selection or allocative efficiency is not a responsibility that central policy makers will be capable of shouldering. It is instead a matter of maximizing the exposure of innovations to the wealth of knowledge existing in markets through entrepreneurial competition to promote a viable selection of projects/firms, partly through entries and exits. This is illustrated by the firm turnover experiments reported on in Sect. 5, but also through forcing positive change on incumbents (Item 2 in Table 1).

The population of actors (firms) was endogenized from the beginning with endogenized exit (Eliasson 1976b), but became fully endogenized when Taymaz (1991a: 63f, 199) made firm entry dependent on the expected industry profitability. This endogenous evolution of the populations of agents (by quarter) from an initial state reflects the intensity of entrepreneurial competition, and of course also defines the utter and unpredictable complexity that I associate with an evolutionary model (See further Supplement).

2.5 Restless Competition Moves the Model Economy

The totality of an endogenously evolving experimentally organized economy can now be visualized by combining the analogue of a Salter curve in Fig. 1 with the Creative destruction process in Table 1, exactly as the dynamics of this economic system is also expressed in mathematical language in the Micro to Macro model to follow.

Extreme diversity across micro agents and over time characterizes a healthy progressing economy, and this diversity exercises a fundamental influence on the progress of the entire economy. To model this economy it has to be characterized (measured) by its initial state, a diversity that in a healthy economy is then replicated without losing its complexity. In fact, and as a corollary to the Särimner proposition, diversity will rather increase. Two conclusions can now be drawn:

1. At each point in time large numbers of incumbent and potential firms challenge each other along the Salter curves. If not protected by natural or legal monopolies there is **no rest anywhere**. Each actor has to constantly attempt to overcome its competitors to the left through innovative performance in order not to be overtaken. And each actor is threatened by actors to its right that attempt to avoid the competition through innovation.
2. Since not everybody can be superior, firms edge upwards the Salter curves, or are competed down along them. New firms enter (Item 1 in Table 1), *subjecting the whole population of firms to competition* and force change in the form of reorganization and rationalization (Items 2 and 3), or if hopelessly inferior to begin with, force them to exit (Item 4) together with incumbents that have failed in the competition. As a consequence the Salter curves shift outwards from period to period. Macro economic growth occurs.

Together this becomes a highly nonlinear economic system, the dynamics of which is governed by competing incompatible choices and selections. This economic system has no external equilibrium solution. If pushed too hard for a "market clearing solution" the model economy is likely to collapse (Eliasson 1991a); an "infinite regress" occurs. Complexity therefore rules in the EOE, and economic mistakes at all levels abound, including at the policy levels. Ambitious policies based on advice from empirically faulty economic theorizing is however potentially far more harmful to the economy (because of the large resources moved around at that level), than the many individual business mistakes that cancel against the business successes, many of which would not have been realized if not accompanied by the mistakes. Since this characterization is inherently empirically reasonable, it also becomes important to keep it as a characteristic of the Micro to Macro model approximation of an Experimentally Organized Economy.

3 The Swedish Micro to Macro Model MOSES

The Micro to Macro modeling project MOSES was initiated by IBM Sweden in 1974 with the accompanying message that a generally felt sentiment in the Swedish business community was that of a lack of understanding among politicians and academics alike of the role of business actors and entrepreneurship in economic development. After my field study of business economic planning practices (published as Eliasson 1976a) I was inclined to agree. I was in fact very enthusiastic about the proposition, and found no problem to get acceptance for my personal demand that the macroeconomic system should be based on the explicit behavior of micro agents in dynamic markets, even though there was no such model to be found in the global academic community. It was also understood that the model should preferably be economy wide, dynamic, empirical, and relate to some known economy, an ambition that my doctorate work at IUI made me willing to accept, even though that ambition made the Micro to Macro modeling project much larger than I originally understood. In the process of setting up the project in 1974 and 1975 Kenneth Arrow was very helpful in getting me in contact with economists in general positive to my ambitions, among them Richard Day, Harvey Leibenstein, Herbert Simon and Sidney Winter.

My doctorate thesis (1967, 1968) on the econometrics of investment plan realizations in Swedish manufacturing had set me on the Swedish School track early, and my field study (1976a) on business economic planning practices, made it clear that Micro based Macro economics was the only way to achieve serious progress in economic theory, an orientation that however ran against the ideas of most Stockholm School economists. The experience from my field study went directly into the specification of the agent decision models, and experimenting with the model told me that pursuing market self regulation of the economic system was the theoretically right way to proceed. The non linear complexity of a complete selection based economic systems model, and the consequent non existence of a traditionally defined exogenous equilibrium, was something that simply had to be faced. Progress in computer science also soon made reliance on the traditional mathematical tools less important.

The project was first located at the Economic Policy Department at the Federation of Swedish Industries, that I headed at the time. In the business community it was rather considered an obvious fact that such a modeling project should have a micro foundation to be capable of saying anything meaningful on how the dynamics of an economy functioned from the market level and up to long term macro economic growth. The academic home of the project first became the University of Uppsala, before the project followed me in 1977 to the Industrial Institute of Economic and social Research (IUI) in Stockholm. Without the generous programming and computer support of IBM the project would however have been a hopeless proposition, and without the Planning Survey to Swedish manufacturing firms, initiated for the project at the Federation of Swedish Industries, it would not have been a feasible empirical proposition.[6]

To achieve an *economy wide understanding* of economic dynamics the micro based manufacturing industry was placed in the midst of an existing, but for our purpose modified eleven sector Keynesian–Leontief CGE type model of the Swedish economy developed at the Industrial Institute for Economic and Social Research (IUI).[7] The Micro to Macro model structure was however such that any part of the CGE sector model could be converted into micro and be populated by individual firms, if the micro data were available. Thus Johansson (2001) carved out the Swedish Computer & Communications (C&C) industry from the service

[6]The solid columns in Fig. 1b are firms that exited the firm population when the MOSES model was simulated from the base year 1982 to create a synthetic data base for 1990 available externally for public use (Taymaz 1992a).

[7]That model was eventually published in Ysander (1986).

production sector and combined it with existing C&C firms in the four manufacturing markets for his Micro to Macro analysis of growth in that industry.

The Swedish Micro to Macro model therefore became a business division and firm-based economy wide Macro model, initialized on a consistent Micro to Macro database, and calibrated ("estimated") against Swedish national accounts data. Work on the model began in late 1974, and MOSES, for Model of the Swedish Economic System soon became the acronym for the model. While the original design of its dynamic core still remains intact, its *modular design* with well defined interfaces has allowed a number of realistic later improvements of its specification. And this presentation of the model will focus on how it looked in the late 1990s when the population of firms had become fully endogenized with both endogenous entry and exit, and an early version of endogenous innovations and the Särimner proposition "installed".

From the start the ambition of the project was to understand the micro entrepreneurial dynamics of a market economy that was growing endogenously through competitive selection. This dynamic core was designed on the model of a Schumpeterian Creative Destruction as stylized in Table 1 (Eliasson 1977, 1978a, 1985, 1996b). One important concern was to explicitly account for the economy wide consequences of both the behavior of business agents in markets and the presence of a large non market and inflexible public sector in a "mixed economy". So economy wide long run (dynamic) competitive selection became key concerns. *For this it was necessary both to begin at the micro market level and "aggregate up", and to move far beyond partial analysis.* Besides that, the preoccupation of the economics profession at the time with large scale macro modeling had created an obvious need to take economy wide economic systems analysis down to its micro economic foundations. Since aggregation by definition reduces the information content of a data base, and notably the diversity of its structure, Micro to Macro analysis can be seen as a method to exploit the information content of available data better (Klevmarken 1983). As a consequence we decided to begin at a micro level where autonomous business decision makers could be defined empirically, their behavior studied, and their internal statistical information system accessed for information. My own field study of business economic planning (Eliasson 1976a) was of course extremely useful here, not only for information access, but also for not getting locked up by the priors of neoclassical micro economic theory. Aggregation above all eliminates the heterogeneity that figures so importantly in the market allocation of resources in an economy. To exclude that information from the analysis on a priori grounds the possibility to understand the role of agent behavior in a market economy is eliminated and almost as scientifically unsound as to believe that macro economic growth can be explained solely in macro economic terms.[8] *Economic growth can be described by Keynesian macro aggregates, but to understand it analysis has to be taken down to the micro level* where decisions are taken (Eliasson 2003a).

[8]Even if Keynes, and notably some of his followers, entertained that idea.

By going micro we therefore expected to open up a vista of new analytical opportunities. The Micro based Macro model was also found to be ideally suited (1) for the study of evolutionary historic processes in which economic, technical and institutional circumstances interact in markets, and (2) to answer questions of the type: What happens to the economic system if it is subjected to particular micro events, or the enactment of particular policies, when it is important to capture the economy-wide and dynamic (over time) consequences. Dynamic cost benefit analysis of policy programs was one example. Economic forecasting was, however, one application that we gave up from the beginning, and for reasons I will return to below.

Empirical application and quantification were an early concern, and a criterion for that was that the entities of the model be observable and measurable. So the firm or business agent was defined as a hierarchical decision system with its own statistical information system[9] that could be accessed through the Planning Survey of the Federation of Swedish Industries. The rationale for that definition of a micro agent is that the firm as a financial decision system is a fairly stable entity that reorganizes itself in response to external market events through mergers, acqusitions and divestments (Eliasson and Eliasson 2005) but can be observed statistically as an evolving entity. In principle we disliked to play around with unmeasurable concepts.

The empirical foundation of the MOSES model was further reinforced by placing the model in a macro national accounting framework. This also allows me now to use the familiar CGE model as a pedagogical reference to present the Micro to Macro model as the desirable counterpart to the GE model that Hansen and Heckman (1996) asked for. The engineering firms populating four markets are however the engine that endogenously moves the entire Moses economy. So my presentation will begin by putting empirical economic life into the accounting or measurement frame of the GE or Keynesian–Leontief (K–L) model shown in Fig. 2.[10] Beginning with this bird's view of the Micro to Macro model also serves the two purposes of demonstrating that the GE model (1) is a special case of the Micro to Macro model when stripped of "economic life", or "evolutionary dynamics". (2), by being almost devoid of economic content, to quote Hansen and Heckman (1996), the CGE model also becomes a useful accounting framework for economic analysis.

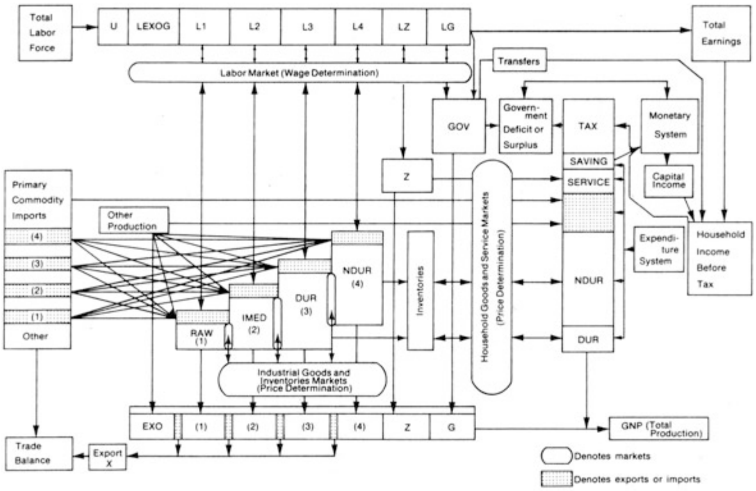
After having presented this bird's view I go through the most important model modules briefly, one at the time, and then tie up the presentation in terms of the model's dynamic systems features. Since the model has been published in many bits and pieces over the years, this document also serves the purpose of presenting "a whole". Since the space allowed for often important detail is limited, the reader will have to excuse the many references for technical detail to myself and my collaborators.

[9]Parallel work on a matching household decision system data base was began early (Eliasson and Klevmarken 1981), but has so far only resulted in a unique data base (The HUS project), and a number of econometric studies not directly related to the Micro Macro modeling project.

[10]To make the point of the 40 year anniversary I will throughout the text use the diagrams from the first MOSES model as they were published in Eliasson (1976b,1977,1978a).

3.1 A Bird's View

When seen from above in Fig. 2 the Micro to Macro model appears as a familiar eleven sector Leontief supply, Keynesian demand (K–L) feed back model, and when stripped of further economic content, such as Keynesian private demand feed back, an eleven sector CGE model. A consistent production, financial and labor supply eleven sector Micro to Macro accounting framework has been put together for the initial year of each simulation experiment (Albrecht et al. 1992). Since the Micro to Macro model is (partly) populated by "live" observable and behaving firms facing each other in product, labor and financial markets, the Swedish input output table has had to be redefined on the OECD end use classification to be compatible with the internal firm data used by, and collected from the firms (Ahlström 1978, 1989). As can be seen from Fig. 2 manufacturing industry in this CGE accounting framework has been divided up into four markets; Durable investment goods (DUR), Intermediate goods (IMED), Non durable consumption goods (NDUR) and Basic industry goods and raw materials (RAW). (For practical reasons the exogenous variables will be presented together after the dynamic properties of the model have been discussed, and before Sect. 4 on calibration).



Micro to Macro delivery, income determination and financial flows structure of MOSES. Sectors (Markets) populated by micro agents: 1. RAW = Raw material production; 2. IMED = Intermediate goods production; 3. DUR = Durable household and investment goods production; 4. NDUR = consumer, nondurable goods production.

Source: Eliasson (1980)

Fig. 2 A bird's view of the Micro to Macro model

3.2 The Micro Decision Units

The macro aggregates of each of the four micro defined industries have been carved out in product, labor and financial dimensions, and have been replaced by real firms from a special survey conducted annually by the Federation of Swedish Industries. The firm data have been collected from the firms' own internal statistical information systems, and individual firm decisions are modeled on the basis of what firms know from their own statistical information systems as short term (budgeting) and long term investment planning models, all as observed in more than one hundred interviews with US, European and Japanese firms (in Eliasson 1976a), and in Fig. 3.

Real firm data are added up in all dimensions for each industry the initial year and the remaining residual firm in each market has been chopped up into several small synthetic firms where total size distributions of firms in each industry to the extent possible have been preserved the initial year. Statistical ex post Micro to Macro accounting consistency in all three market dimensions (product, labor and finance) could thus be achieved for the initial year, and is maintained ex post throughout quarterly simulations. New initial conditions after the starting quarter are endogenously redetermined through the simulations each quarter.[11] Ex ante expectations of individual firms rarely add up consistently, and ex ante ex post differences are the major element of dynamics of the model; one heritage of the Swedish/Stockholm School.

3.3 Production System of a Firm

The production frontier $Q = QTOP\ (1 - e^{-\gamma L})$ of each firm is shown in Fig. 4. Q is production (value added in constant prices), L is labor input and γ defines the curvature of the frontier (Eliasson 1977, 1991a[12]). New technology enters through

[11] In a growth simulation some initial circumstances, such as plan realization differences, may cumulate over time, as may also measurement errors in the initial state. Plan realization differences represent market "disequilibria" that reflect the dynamic evolution of the model, but not the measurement errors. Good quality initial state measurement therefore is critical for the empirical characteristics of simulations.

[12] In this verbal presentation of the model I have kept the mathematics at a minimum. Eliasson (1976b) includes a complete early mathematical specification of the model. In addition there are *five* technical *MOSES books* (Eliasson 1985; Bergholm 1989; Albrecht et al. 1989, 1992; Taymaz 1991a, b) that together give a complete state of the art mathematical presentation of the MOSES model through the mid 1990s, including the major updating during the early 1990s, introducing endogenous entry. Learning, human capital accumulation, innovation and endogenous technical change using genetic algorithms was entered by Ballot and Taymaz (1997, 1998). The *five MOSES books* are unfortunately either out of print or difficult to find. All MOSES related publications published from 1976 through 1994 can however be accessed on line, either from the home page of IUI/IFN WWW.IFN.se/eng (under English publications), or from the journals where they were published. For technical detail I will, however, in the first hand make page references to

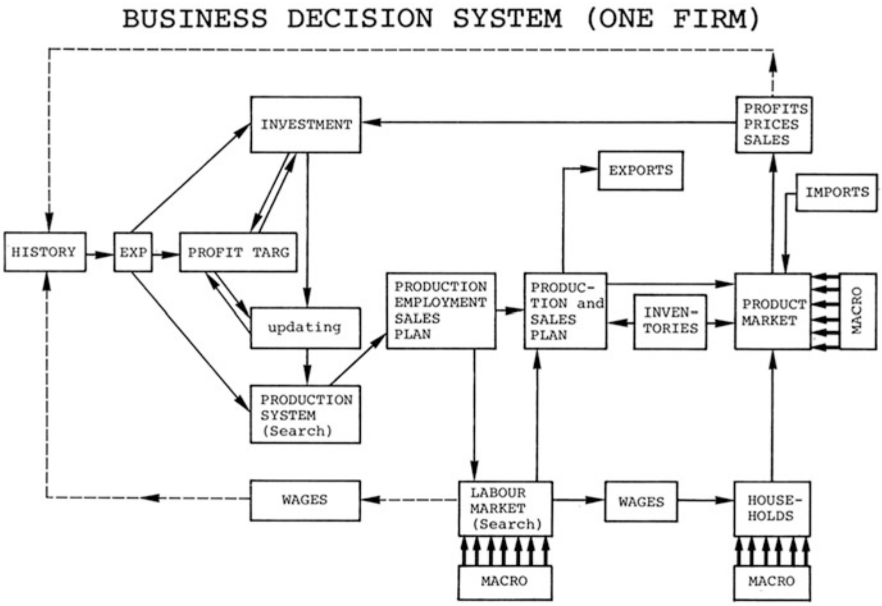


Fig. 3 Financial planning (budgeting) system

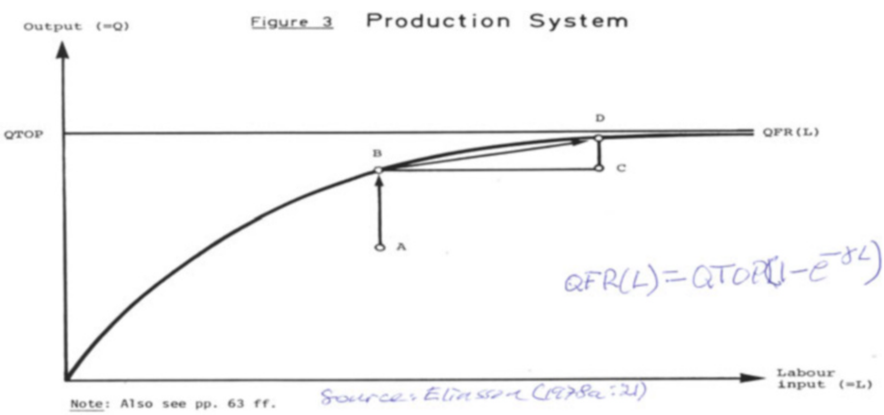


Fig. 4 MOSES production system

publications that are fairly easy to access. They are Eliasson (1977, 1980, 1984, 1991a, 1992) and Ballot and Taymaz (1997, 1998). Also see Ballot et al (2014) for a survey of related Agent Based or Micro to Macro models.

the upgrading of γ.[13] This gives QFR the desired convexity properties and defines the marginal productivity of labor to be γ QTOP in origin. A is the firm's operating position. Both A and QFR are estimated for the initial year on data collected annually in the special Planning Survey of the Federation of Swedish Industries, and then reestimated each quarter on firm investments endogenously generated throughout the simulation. The planning survey questionnaire was originally designed on what I had learned about internal statistical information systems of firms (in the field study Eliasson 1976a), and on the format of the MOSES Micro to Macro model. Firms were always found to be operating far below the estimated frontier, signifying constantly unused production capacity. Competition, however, ensures that firms are constantly striving to move closer to the frontier through reorganizing themselves and rationalizing (Items 2 and 3 in Table 1), thus pushing the frontier further upwards through investment and the introduction of new technology.

3.4 Expectations

For the Stockholm School economists the distinction between ex ante and ex post (see Myrdal 1927 in particular), and the role of expectations in shaping the economy were basic. Ex ante plan incompatibilities forced plan realizations to be modified. These "realization functions" are central in the MOSES model which features individual firms drawing up their ex ante expectations of prices, sales and wages on the basis of past experiences to convert history into future projections. To this an extra "caution correction" was added that depended on the magnitude of previous expectational errors, and the volatility of the price, sales or wage histories. Conventional smoothing algorithms are used. There is also an option to incorporate extraneous information on what other firms know and are doing (Eliasson 1977, 1991a: 161f), and expectations can be modified to include exogenous considerations, and "learning from" or imitating competitor firms.[14]

3.5 Ex Ante Profit Hill Climbing in an Endogenously Changing Competitive Business Environment

Individual firms set up their own profit targets based on the principle that past rates of return be restored, maintained or preferably improved. This *Maintain or Improve*

[13]Since the production frontier shifts outward by investment, $Q = QTOP\,(1 - e^{-\gamma L})$ can be derived from a generalized CES-type production function with capital stock explicit.

[14]On one occasion managers from several Volvo divisions participated in a calibration game where they set their own expectations, profit targets and parameters.

Profits (MIP) targeting principle was almost universally observed in the more than hundred interviews reported on in Eliasson (1976a: 159, 236ff). Given expected prices (P) and wages (W) a minimum labor productivity (Q/L) line can be computed and entered in Fig. 4.[15] Management can also modify its profit target by observing the performance of other firms, or to accommodate changes in the interest rate. The latter is important in that when firms happen to be challenged by superior firms, they may be forced to opt for a high risk, innovation expansion strategy that will succeed if the innovation experiment succeeds, and fail if the opposite occurs. Alternatively firms can also opt for contraction, or even exit if a positive outcome does not generate satisfactory expected profits. On the other hand high rate of return firms tend to be bolder and opt for high risk expansion strategies, and they may be sufficiently profitable to survive even if the strategy fails (Ballot and Taymaz 1998: 312). Within the area above the upward sloping line, and below the feasible production frontier the firm finds itself in an ex ante satisfactory profit situation. When the operating point is below, it strives to move itself inside the satisfactory range by raising productivity, either by lowering planned production and laying off labor, or by investing and scaling up. The labor market production search process was quite elaborate from the beginning in that we attempted to represent Swedish labor market rules as closely as possible (see below).

The unique Swedish Stockholm School feature of the MOSES model is that the ex ante profit hills that firms are attempting to climb change endogenously because of all the climbing going on. As a consequence firms constantly commit production planning and investment mistakes in that the expected upwards profit climb may turn out a decrease in ex post profits. These ex ante plan and ex post realization differences then feed back into next period's decision making.

3.6 Competition, Business Turnover and Endogenous Populations of Firms

Investment in incumbent firms and new firm entry puts competitive pressure on the entire firm population in both product and labor markets (Item 1 in Table 1). Firms may suddenly find themselves outside the satisfactory operating range in Fig. 4 and are forced to rationalize and/or reorganize themselves (Items 2 and 3), or, if unsuccessful, exit (Item 4). From the outset innovation was present in the model through exogenous Schumpeterian entry, together with endogenous exit (Eliasson 1978a: 52ff). As a matter of curiosity, and an instance of "surprise economics" (Sect. 5) it should be mentioned that the early academic seminar "trials" of MOSES specifications revealed a more or less compact disinterest among participants in having innovation and entrepreneurship economics represented in the model. The advice

[15]Demonstrated graphically and mathematically in Eliasson (1991a: 160 f). Also see Eliasson (1977).

was to turn off the entry module, which we did for some time, soon to discover that the loss of diversity in MOSES structures (with no entry, but exit) soon pushed the entire model economy into unstable systems domains, that again disappeared when the entry mechanism was turned on (Eliasson 1984, 1988, 1991b; Hanson 1989).

Endogenous innovative entry [as introduced in Taymaz (1991a: 59ff), Ballot and Taymaz (1998) and Eliasson and Taymaz (2000: 274)] represents the most forceful competition that (under the Särimner proposition) keeps all incumbent firms constantly restless and on tip toe to improve their positions, and the economy constantly and endogenously evolving/growing.

3.7 Labor Market Matching

When the Micro to Macro modeling project was initiated 40 years ago mobility and flexibility in the Swedish labor market had been increasingly restricted by regulations, that were later gradually softened, as their destructive allocation effects on the economy were understood. In the original labor market search module (Eliasson 1978a: 73ff), however, the productivity of the worker was determined by the equipment in the firm that s/he operated, a specification that was empirically acceptable at the time, but is no longer, as job performance is increasingly determined by the "entrepreneurial qualities" of the worker (Eliasson 2006). Originally both wages and productivities therefore increased as high productivity firms recruited labor from less productive firms, and from the pool of unemployed. The labor market could then be presented as a dynamic market for workers´ services that could be modified as desired to correspond to the various imperfections that characterized normal labor markets. This meant that the labor market of the Micro to Macro model was more of a market for labor than in reality. The modular design of the model has however made it possible to introduce different regulations as they have been introduced in reality.

In the original labor market search module firms made up their production plans and gradually offered new jobs at their expected wages. Labor supply was forthcoming from other firms if wage offers were significantly (the coefficient can be varied, but has been set on the basis on studies of *reservation wages* made) above the wages of their current employment, and from the unemployed if the wage offered was significantly above unemployment insurance benefits. Firms, however, gradually modified their wage offers upwards when they couldn't recruit the labor they needed, and wages drifted upward. In the opposite situation, when the firm was planning to reduce production and laying off labor, laid off workers were allocated to the pool of unemployed.

The original specification of the labor market search module included the only stochastic element of the model in that firms were ranked in descending order according to their wage offers. The market was then stochastically informed about the wages offered in that order each quarter.

Labor market matching could be modified in many ways to incorporate the new regulations enacted during the 1970s and 1980s. One of the first simulation experiments (Eliasson 1977) was on the new regulation (The “Åman law”) that required firms to give 6 months’ notice before labor could be laid off. The experiments showed this regulation to slow macro economic growth and demand for labor, thus counteracting its original purpose. Furthermore, if decision making in firms was characterized by tough (rather than soft) profitability targeting, the device both prompted firms to look for more productive plans through lowering output, or expanding output through investment, and/or to restore profitability by lowering wages. The long run effects on their rates of return were marginal, and most of the incidence of the Åhman regulatory device fell on wages.

During the early 1990s Ballot and Taymaz (1996, 1997, 1998, 1999, 2000, 2001) introduced workers’ training, learning and human capital accumulation that not only raised firms’ capacity to innovate and choose the right technologies, but also to learn from each other, and thus raised the performance of the company. Those improvements have moved the labor market specification closer to what it really is; a market for competence (Eliasson 1990a, 1994, 2006).

3.8 Investment, Innovative Technology and the Särimner Effect

Investments in each firm is governed by its expected profitability and brings in new technology that both shifts the production frontier outwards, and changes its shape at a rate determined by best practice technologies available in global markets. To begin with the best practice technologies were externally given through a survey to Swedish manufacturing firms conducted by the Industrial Institute of Economic and Social Research (IUI) in cooperation with the Swedish Academy of Engineering Sciences (IVA), and reported on in Carlsson et al. (1979) and Carlsson (1981). Until the mid 1990s exogenous best practice technologies were brought into the individual firms through their endogenous investments, and improved labor and capital productivities shifted and reshaped the QFR frontier (Eliasson 1991a: 165ff). Technology change was endogenized by Ballot and Taymaz (1997, 1998) who introduced investments in R&D and in both general and specific workers´ training to raise human capital. This way the technological *receiver competence* and the ability of firms to capture and exploit globally available technologies was raised, as was their endogenous capacity to innovate in radically new technologies. Because of the quasi rents generated by successful radical innovations it became profitable for firms to invest in general training despite the increased risk of losing now better trained labor to poaching firms. The increase in general human capital had both raised the innovative capacity of the firm, and its capacity to pay higher wages (Ballot and Taymaz 1997: 205/3).

With Ballot and Taymaz (1997, 1998) investments in R&D and employee training were added to investments in physical assets and financial assets. Total investments so defined were made dependent on the profitability of the firm, the interest rate it had to pay on borrowed funds and its size, very much as physical investments had been previously determined. Together the difference between the expected rate of return on total assets and the borrowing rate, individual to the firm, now determined total funds available for investments. The share of total investments allocated on R&D was in turn made dependent on its stock of general human capital and the firm's propensity to pursue radical innovations. Investments in training or human capital were in turn made dependent on the existing stock of human capital, the inverse of unused capacity to manufacture, and the size of the firm measured by sales revenue.

Through R&D investments and investments in (general) training the best practice technologies brought into the firm through physical investments could now be endogenized. Using genetic algorithms the technological level of a firm was determined in relation to the "global technology" level of best practice technologies within the technological paradigm the firm was operating. The closer to that globally best practice level the more of the R&D investments the firm would direct towards investing in the creation of radical innovations. The probability of successful outcomes of that strategy now depended on the firm's stock of general knowledge, or receiver competence (Ballot and Taymaz 1998: 307, 313f), investments in which are also endogenous and determined as R&D. The firm's probability of successfully creating radically new innovations also depended on its capacity to pick up spillovers from other firms (Ballot and Taymaz 1997: 205/11), which in turn depended positively on the same general human capital or receiver competence. By hiring from firms with a higher per employee level of human capital the hiring firm could increase its own level of human capital, but then it also had to be capable of paying the higher wages that this firm was paying. Together all this meant that *the best practice technology of a technological paradigm* (a global technology) *was endogenously pushed upwards*. Since the opportunities space is composed of all best practice technological paradigms *the opportunities space is* also *endogenously pushed upwards*, possibly faster than it is being searched, thus preventing the Micro to Macro model economy from collapsing into a CGE model.

3.9 Private Consumption Demand and the Tax System

For decades Sweden has taxed its citizens more than any other country. To obtain a "Sweden like" Micro to Macro model economy the progressive Swedish personal income tax system had to be reasonably well represented, and this also required that Keynesian private demand feed back be properly represented. The latter was done in macro (all "representative" households were assumed to be equal), using a marginal tax rate function developed by Jakobsson and Norman (1974) to calculate disposable income (after taxes and transfers) from the endogenously determined wages, and fed through a Stone type household expenditure system. An estimated linear version of such a system was brought into the MOSES model from Klevmarken and Dahlman (1971), modified somewhat to add a non linear consumption component that maintained stable consumption ratios to real income in the long run ("habit formation"), and complemented with an extra *savings/insurance balance* that maintained a long run stable relationship between household financial wealth and disposable income. The latter corresponded to a Modigliani–Brumberg type life cycle permanent income savings behavior in which savings could be said to *represent a demand for future consumption*. In addition, households could swap between saving and buying durable consumption goods (such as cars) over the business cycle depending on the interest rate. In the end, final ex post quarterly saving was residually determined (Eliasson 1978a: 76ff, 1985: 218ff). We also found it quite interesting to experiment with the adjustment dynamics and the changes in resource allocations associated with a change in the Swedish tax system (Eliasson 1980) from an emphasis on payroll taxes to value added taxes, and to study the macro economic consequences of varying various tax parameters.[16] [It is interesting to note that the progressiveness of the Swedish income tax rates affected the calculated cost benefits of the industrial support program of defunct shipyards in Carlsson (1983a, b), a study that we revisited in a companion paper to this in Carlsson et al. (2014).]

3.10 Financial Markets

From the beginning the standard MOSES specification featured firms depositing their cash surpluses, and borrowing in "the bank" at individual interest rates that depended on their endogenous debt equity ratios. Over the years the financial system has been improved upon to introduce parts of the competence bloc (venture capital. Ballot et al. 2006), a stock market and a financial derivatives market (Taymaz 1999; Eliasson and Taymaz 2001). On this Broström (2003) demonstrated that the Capital Asset Pricing Model (CAPM) was utterly unreliable when the economy operated away from what could be called a capital market equilibrium (i.e. when there was a wide spread in the ε in Fig. 1B) which is the normal situation both in reality and in MOSES simulations, and has to be so for sustained economic systems stability.

[16] A fairly detailed presentation of the tax system of the model as it still looks is presented in Eliasson (1980) together with the simulation results.

3.11 Moses Goes Global Through Spillovers and Trade in General Purpose Technologies

Recently Ballot and Taymaz (2012) have cloned the Moses model into ten national models that are linked by spillovers and learning across national boundaries. They combine the already installed mechanism of endogenous radical innovation creation with a more or less generic technology spillover feature, and thus are able to link the economies through the global diffusion of technologies. Interesting new and realistic (observed) economic developments, referred to as stylized facts, are simulated. Ballot and Taymaz therefore take exception to the Solow (1956) and Swan (1956) type models that feature convergence among national economies by assumption. Quite the opposite, they argue, divergence is what you see around you, and should be a possibility embodied in both theoretical and empirical models. Poor countries do not generally catch up to the wealthy industrial economies, and clusters of close and equally wealthy and structurally similar neighboring economies that they call “clubs”, may rather race ahead of the rest of the world.

Since Ballot and Taymaz (1998) the Moses model has been equipped with a spillover/learning feature among firms with similar technologies, a feature that is now enhanced with a geographical proximity feature. Since some technologies are more generic and spillover intensive than others interesting evolutionary growth patterns arise that are not stochastic, as they are in all other similar models, and seem to match the stylized facts reported in empirical literature better.

3.12 Non Linearity, Path Dependency and Economic Turbulence Demands Precise Economic Measurement and Credible Estimation by the Analyst

The Moses model economy is highly non linear. It evolves endogenously through competition driven firm turnover and selection carried by the Schumpeterian type creative destruction process stylized in Table 1, and the entire spectrum of Micro Macro market transactions is fed back for a new decision round each quarter. It is therefore initial state and path dependent and features endogenous populations of firms. *Such models are empirical since their initial state has to be measured before a simulation experiment can be run, and with that a case economy has been characterized, that should preferably feature characteristics that belong to a real economy*. Model simulations also exhibit unpredictable phases of turbulence or chaos, and not least the surprise economic systems behavior and the Wicksellian Cumulative process that I address in Sects. 5 and 6 respectively, surprises that are not properties of the received economic models, but may still be quite realistic features that should not be assumed away from the analysis.

Since chaos economics by definition means that there is no way to derive the underlying model that generates the chaos from observed data during the phase of turbulence, once the economy has entered such a phase, initiated perhaps by a sometimes small disturbance or policy action decades earlier ("the butterfly effect") policy makers will have practically no informed way to correct a socially undesirable economic systems behavior once it has begun. Since turbulence is equally impossible to predict, since it may have originated in a small disturbance a decade or so before it shows up, the policy maker will be stuck in a Catch 22 situation, being likely to do worse in the long run, when trying to do better in the short run.[17] Since the origin of economic turbulence cannot credibly be established, and since worse chaos may be created in the long run by actions to contain it, there is a policy morale to pay attention to. *To minimize socially undesirable economic systems behavior "caution", not "ambition" should be the general rule of policy.*

3.13 Exogenous Variables and Economic Systems Behavior

The evolutionary features of the micro to macro model give it uniquely different dynamical systems properties compared to the standard macro models of economics. Exogenous variables, however, keep this surprise behavior within bounds. Some of them are currently being endogenized to make the model more general, but still serve the same purpose.

The five important sets of exogenous variables are:

1. The initial state variables that we measure directly through a survey
2. The labor force
3. The global environment assumed to be in a steady state foreign prices and interest rate equilibrium
4. The global pool of best practice technology
5. Policy

Global conditions 3 and 4 have to be consistently specified over future time for that equilibrium to obtain. Thus, (until Ballot and Taymaz 1997), best practice technology, expressed as total factor productivity in the global pool of technology for the four micro markets that firms tap into through their investment decisions, was determined such that the rate of return of marginal investments in those best practice technologies equaled the global interest rate ex post (Eliasson 1983: 313, 1991a). Locally, firm by firm expectational errors, different individual (endogenous) prices and interest rates, linked to the global price environment through export/import and trade credit transactions, and firms´ own wage setting practices violated that equilibrium rate of return constraint ex post. The exogenous steady state global rate of return restriction on new best practice investment vintages was endogenized and significantly modified with Ballot and Taymaz (1997, 1998). As

[17] In one very early analysis of chaotic economic behavior (Ysander 1981) tax wedges that distorted the price system was the initiating factor.

described above this allowed firms to improve on globally available technology (productivity) through more or less radical R&D investments, and learning from one another, and in such a way that the global opportunities space was positively affected. Work is currently under way to further endogenize the business opportunities space along the lines of the Särimner Proposition. The Ballot and Taymaz (2012) paper can furthermore be seen as a step in the direction of endogenizing the global technology pool by allowing sophisticated MOSES firms to contribute improved technologies to that pool.

In general policy making is treated as an exogenous input in the Moses model and a general experience from work on the model that will be discussed below is that the Moses model economy, due to its complexity and non linear market intermediated selection processes is extremely difficult to control through exogenous policy, in the fashion taken for granted in Keynesian policy models (Eliasson 1983). Misunderstanding the evolutionary dynamics of the model economy may drastically raise the risk of policy failure from interfering with its self regulating market mechanisms.

As long as the exchange rate of the Moses economy is fixed the global economy exercises a restraint on excessive surprise economics of the Moses model. A possible pedagogical value of static equilibrium economics is perhaps illustrated by the final discussion in Sect. 6 of the Wicksellian Cumulative process where the exchange rate constraint is lifted.)

4 Estimation, Calibration and Empirical Credibility

Throughout the large part of the 1980s simulation experiments on MOSES were first run on mainframes, and then on a Prime minicomputer. In the beginning even 5 year experiments by quarter, involving less than 100 firms required overnight use of IBMs largest computer system in Europe, which would have been prohibitively costly on an academic budget. Limited computer capacity thus prevented us both from ascertaining that simulations behaved well over the long term, and from carrying out Monte Carlo experiments to check the initial state sensitivity of model trajectories. Since the late 1980s PC technology has taken care of these practical problems, and an advanced PC can now accommodate a population of firms in the thousands, 100 year simulations by quarter and very elaborate parameter calibration using Monte Carlo experiments (Taymaz 1991a, 1992b, 1993). From the beginning "surprise" behavior of the MOSES model economy (Sect. 5) arose skepticism in the academic reference group, and we had to make up our minds on the empirical credibility of what the model told us (Eliasson 1978b, 1983, 1984; Klevmarken 1978).

Early on, efforts were made to investigate the existence of an external "equilibrium" steady state within the Moses model, which was argued from the academic audiences to be desirable. More precisely, could the model equations be solved for such a steady state? We understood intuitively, before sufficient computer capacity became available, that we would not "find" such a steady state, and that we did not want it. Neither should evolutionary models be solvable for equilibrium steady states (see Supplement). In fact, we found early that forcing the model too close to a capital market equilibrium where all firms operated at roughly the same rates of return, and barely above the interest rate (all {ε} in Fig. 1b being close to zero) positioned the entire model economy in a collapse-prone mode. Without entry, model structures fast lost diversity and became highly sensitive to even small external disturbances, and again collapse-prone (Eliasson 1983, 1984, 1991a).

Using an eleven sector Leontief supply and Keynesian demand feed back model (Fig. 2) to frame the micro market based growth engine of the MOSES model (as explained above) *first allowed* economy wide consequences of a micro occurrence to be quantified, even though the transmission of those consequences beyond the manufacturing industry then became linear and conventional. *Second*, this however posed no principal problem. MOSES is composed of empirically defined modules, including firms, linked together by markets. If considered empirically important all sectors can be micro based. It is all a matter of cumbersome and costly data collection, costs that are however in reality almost negligible compared to the social costs caused by mistaken policy action. *Third*, and not least important, there is an instructional advantage to consider. The links to the CGE model and conventional economics that all trained economists are familiar with are now exactly defined. If you aggregate the four micro-defined manufacturing sectors of the Micro to Macro model, and remove the Keynesian private demand feed back you obtain a complete eleven-sector Computable General Equilibrium (CGE) model with an exogenous equilibrium. This eleven sector model is in turn placed in a global economy assumed to be in static equilibrium.[18] If you keep the Keynesian feed back element you obtain the eleven sector model that already existed at the IUI and was brought in to frame the micro defined part of the Micro to Macro model.

To achieve the required Micro to Macro stock-flow consistency the initial year, the I/O table furthermore had to be redefined according to the OECD end use classification to correspond to the internal market-oriented classifications of the statistical systems used in the firms loaded into MOSES the initial year. The firm data was collected in the Planning Survey of the Federation of Swedish Industries (Albrecht 1978a, b, 1979, 1992; Ahlström 1978, 1989).

All CGE models have a calibration problem, and the calibration methods used have been subjected to the harsh criticism of Hansen and Heckman (1996), a critique that affects this model as well, but not to the full extent. We argue that we have carried out credible empirical calculations, so a few paragraphs on the empirical method are in place. The main thing is to be precise about where exactly we depart from a correct estimation protocol. *First*, you have to argue the case for the particular model specification you use (which is the real "art of economics").

[18] There are exogenous global prices for each sector/market determined such that that capital and labor best practice technologies when introduced in firms earn a return on the margin equal to the exogenous global interest rate (Eliasson 1983: 313).

That specification then enters your estimation procedure as a priori assumption and conditions all parameter estimates. (Moses is *no universal model*, but it is sufficiently general to embody most of the general characteristics of an evolutionary theory that we attribute to an Experimentally Organized Economy (EOE), and to enclose a CGE, or more generally a Keynesian–Leontief (K–L) model as a special case. So before an empirical application one has to argue the advantages of a Moses choice, or the reasons for not using one of the special cases. There is also the possibility of studying the sensitivity of simulated outcomes to Moses parameters, and features that distinguish the full scale Moses model from its special cases.) *Second*, we should resist modifying the model specifications to facilitate proper estimation. Then specification and estimation errors won't mix unmanageably. Even though rarely practiced, it is a great analytical benefit if both errors can be made explicit in the estimation or calibration procedure. Estimating the wrong model perfectly is no merit. Estimating the right model less than perfectly is a problem that can be dealt with. This refers exactly to the accompanying paper on the Swedish industrial subsidy program 1975–1984 (Carlsson et al. 2014). The empirical problem of estimating the social costs incurred in that program relates solely[19] to the "estimation" or "calibration" of parameters to obtain an "empirically credible "Micro to Macro, or agent-based model representation of the Swedish economy. Table 3 describes the calibration procedure.

There are four principal calibration, verification, estimation and testing problems to address. *First*, the exogenous assumptions have to be presented (Items 1 in Table 3). *Second*, the hierarchical structures of both the economy wide model and the firm decision system have to be specified (Items 2 and 3). Together that makes up the a priori specifications of the model that have to be credibly argued *before* parameter calibration/estimation begins. The business decision module of the firm models involves specifying

– The internal firm-to-firm interfaces, and firm-to-market interfaces, and
– Market processes, *how ex ante plans are confronted and realized in dynamic market confrontations*. (This is one place where the influence of the Swedish/Stockholm School heritage is reflected.)

That micro specification is part of the overall specification of the total economic system that has been carefully researched prior to the design of the Micro to Macro model (as documented in Eliasson 1976a).

Third (Item 4), initial conditions have to be consistently *defined and measured*.

Fourth (Item 5), the critical time reaction parameters of firms that also determine Stockholm School feed backs in the model economy[20] have to be "estimated",

[19]And of course also to the choice of the MOSES model which, given the above, is the empirically superior choice to other kinds of conventional CGE, L&K, or partial models.

[20]Modigliani and Cohen (1961) coined the term *realization function* for that Stockholm School phenomenon, however, without quoting a Stockholm School economist.

Table 3 What has to be measured, estimated, calibrated or assumed?

Exogenous assumptions/forecasts
1a. **World economy** assumed to be on a consistent capital market equilibrium steady state growth path (Exogenous Prices, interest rate) 1b. **Pool of best practice technologies** that firms tap endogenously into through investments [Survey based to begin with Carlsson et al. (1979) and Carlsson (1980, 1981)] Endogenized (the Särimneer proposition. Endogenized through learning and human capital accumulation in Ballot and Taymaz 1997, 1998, 2012) 1c. **External domestic macro environment** (Exogenous 11-sector K&L model)
Internal structures of Micro to Macro model
2. **Hierarchical structures of national micro based model** – Organization of market processes – Modified end use National Accounts and I/O classification (Ahlström 1978, 1989; Nordström 1992) 3. **Hierarchical structure of business decision system** – Internal firm to market decision processes, ex ante profit hill climbing (Eliasson 1976a, and other interviews) – Firm to firm and firm to market interfaces, competition 4. **Initial state measurement** – Individual firm structures [Special statistical survey to firms (Planning Survey of Federation of Swedish Industries, Albrecht 1978a, b, 1992)] – Residual firms to ensure internal micro to macro consistency (Eliasson 1978a; Taymaz 1992a)
Calibration & verification
5. **Calibrating micro to macro time reaction parameters** that move the dynamics of transition over time – Calibration against historical macro time series and micro distributions (Eliasson and Olavi 1978; Taymaz 1991b, 1993) – Monte Carlo experiments to determine long run model behavior (Taymaz 1992b) 6. **Calibration possibility**; Arrange a business game and make real firms enter their own parameters (Volvo)

preferably by a method that makes it possible to determine their stochastic properties.

The first three steps pose no particular problems, except that choice of specification will determine the difficulties of estimation. The exogenous assumptions define what we don't know well, even though the expansion of the opportunities space, or the Särimner proposition, still remains to be endogenized in a sophisticated way. Model specifications under 2 and 3 represent the important "art of setting the priors right", which is a matter of economic knowledge and good common sense. High quality data base work is necessary to minimize measurement errors, because of the sensitivity of the Micro to Macro model to initial state conditions (Item 4). After these three steps estimation of the critical time reaction parameters of individual firms (ten in total, but six of them identical for all firms, at the time of the subsidy study, Carlsson 1983a, b), follows.

At the time of the industrial subsidy study, calibration of the time reaction parameters was done manually as described in Eliasson and Olavi (1978), but in principle executed as in the pioneering calibration program for Micro to Macro models developed by Taymaz (1991b, 1993). Calibration against macro time series data, however, is not sufficient to identify the micro parameters of the model. Individual firms may have different parameters, and there may be several parameter combinations that fit the same time series data equally well. At the time of the subsidy study it was impossible to determine the stochastic properties of the calibrated parameters. Today we also calibrate the parameters against micro distributions of firm characteristics, although that does not solve the identification problem.

We use partial estimates of parameters, which is allowed if there are only negligible *cross-market and over-time interdependencies between micro agents*. Since such interdependencies *define the core dynamics of the Micro to Macro model economy* we deliberately commit a principal estimation error here.

All these shortcomings on the estimation side become part of the "empirical credibility" of the Micro to Macro model. For anyone familiar with the "estimation" of large-scale economy-wide models of the Keynesian type in the 1960s and 1970s, and the CGE models that became fashionable in the 1980s, this problem is known to be universal. Limited computer capacity at the time also prevented us from checking sensitivity to initial conditions with Monte Carlo experiments the way we now do routinely (Taymaz 1992a, b).

The final solution to the problem of estimating and identifying the parameters of complex selection-based dynamic models of the Swedish Micro to Macro type (Item 6 in Table 3) is to do what we once began, but so far have not completed, namely to *organize the entire Micro to Macro model as an interactive evolutionary game* and to invite a sample of managers of the real firms to set their own parameters. This would also make it possible to determine, using small sample methods, the stochastic properties of the parameters. Volvo budgeting and planning management participated in such an interactive experiment in the 1970s, and plans were to expand that activity (Eliasson 1985: 151ff; Taymaz 1991a) that so far, unfortunately, have not been realized.

So even though its principal specification is generic, the Swedish Micro to Macro model becomes empirical whenever implemented numerically, and the empirical credibility of the model, like all models, not only rests on its a priori specifications, the quality of data collection and measurement, and the estimation protocol, but also on how the model is used. It is ideal, if you take the trouble to do a careful calibration/estimation job to quantify the long run economy wide consequences of particular micro events, such as the industrial support program in Carlsson et al. (2014), analyses for which CGE models and K–L models should be avoided. It is of course superior to macro models in general for quantitative analyses of resource allocation problems, and in particular when production structures can be expected to change endogenously over time. In addition, as a general intellectual tool to understand the evolutionary dynamics of a complex market based economic system through simulation experiments MOSES type models is the only available instruments for increased understanding. The best example of this is for the study of "mixed economy" problems and the consequences for the entire economy of an inflexible non market sector, or for investigating the limits of policy control of a complex economic system (see conclusions Sect. 7).

For a highly complex micro based non linear economy wide model with chaotic properties that cumulates errors of measurement and estimation, forecasting, if at all interesting, is of course ruled out, unless one wants to invoke the Friedman (1953) proposition that anything goes as long as the model predicts well, whatever that means. But with such a low ambition, why would you take all the trouble of building and loading a complete Micro to Macro model with data?

Still the Swedish Micro to Macro model, as all other large scale economic systems models, will always have to be a compromise application between a theoretical and an empirical exercise, and the credibility of the model analysis will have to be conditioned by the complementary judgment that has been entered through a priori specification, the quality of the data and errors of estimation; that is on the care, sound judgment and competence of the analyst.

Let us therefore conclude with some apt illustrations that I call *surprise economics,* because they are stories that cannot be told out of received economic theorizing.

5 Surprise Economics

Familiar models of the received type taught at universities across the Western academic world also have familiar answers embodied in their a priori specifications. Depending on their parameter settings the magnitudes of model pronouncements will differ, but for the trained analyst there will be no surprises coming out of his analysis. One "advantage" with the transparent linear CGE or K–L models therefore is that you don't really need much analysis to predict what principal answers the model will give to your queries. Not so with the highly complex non linear selection based, initial state dependent and economy wide Micro to Macro model. It aggregates data both across dynamic markets with endogenous price determination, and over time, and keeps throwing surprise answers at you, or answers that are not embodied in the priors of traditional CGE or K–L models. Part of the reason is the complexity of the model, which is also a natural feature of reality, as current (2015) zero interest zero inflation economics among industrial economies illustrates. So given the estimation problems discussed above let us consider what empirical credibility should be given to some surprise empirical statements the MOSES model has thrown at us over the years on a couple of controversial economic policy issues.

First, in an early policy experiment Eliasson and Lindberg (1981) demonstrated that the costs to society incurred by failed investments, even large ones, are negligible as long as production is shut down as soon as the investment mistake has been identified, and labor reallocated on more promising projects. This reallocation should therefore not be prevented by policy. The large social costs in the form of lost output were incurred when manufacturing was continued in what turned out to be an inferior production facility. [As demonstrated on the MOSES model in Carlsson et al. (2014) a massive drag on the Swedish economy was incurred for more than a decade during the 1970s and 1980s by locking up (skilled) labor in the worst performing large companies through subsidies, to achieve a minor temporary employment benefit.]

Second, a CGE model economy achieves maximum efficiency and utility (welfare) when costs of production are minimized and profits maximized, but eliminated by competition, such that all markets are cleared and rates of return of producers are all equal to the interest rate. In such a capital market equilibrium all excess profits in Fig. 1b are equal to zero (all $\varepsilon = 0$). Such a situation can be approximated on the Micro to Macro model by artificially raising market competition through repeat simulations. The surprise answer is that such an equilibrium does not exist as an operating domain of the Micro to Macro model (Eliasson 1991a), and that the MOSES economic system gets increasingly destabilized as it is being pushed closer to a market clearing situation by competition, eventually to collapse. It was therefore concluded that the state of static capital market equilibrium is entirely undesirable to be pursued by policy. Should you therefore avoid such models, and on what grounds, or what should you do when the journal referees demand that the equilibrium properties of your model be mathematically clarified? Magda Fontana (2010) has an interesting story to tell about the equilibrium syndrome of the Santa Fee Institute which claims to be a pioneer in economic complexity theory. The point she makes is that the closer to challenging the equilibrium the computer simulation analyses of increasingly non linear and complex economic models became, the more reluctant several early sponsors of the Santa Fee institute to embrace its idea became.

Third, Walras introduced the auctioneer, or central planner to make sure that the equilibrium be achieved. Given strict convexities of the production and consumption sets, and continuous derivatives it could be mathematically demonstrated to exist through “repeated (transactions cost less) interactions” between producers and the central planner. The MOSES model needs no central auctioneer to coordinate the economy. It is done by costly self regulation among agents in markets. Coordination, however, does not mean that markets are cleared to allow the economy to go to sleep in equilibrium. To the contrary, Antonov and Trofimov (1993) demonstrated on the MOSES model that centrally imposed coordination to raise static efficiency reduced long term growth by preventing firms from discovering even better opportunities within the opportunities space.

Self regulation over markets draws resources (positive transactions costs), not least due to ignorance, in the form of failed business decisions and systematic differences between ex ante plans and ex post realizations. An illusion of a socially costly organization of the economy is therefore created compared to central planning to clear all markets for a general equilibrium under a regime with (assumed) zero transactions costs (Pelikan 1988). *Transactions costs* in the MOSES model by their very nature have to *include business mistakes* (Eliasson and Eliasson 2005) which are indeterminate, as are then also the evolutionary trajectories the model economy follows. Coordination is thus achieved through competition among all actors of the economy, or by the invisible hand Adam Smith[21] introduced in academia almost 250 years ago. When deprived of its evolutionary specifications markets disappear and a CGE model emerges. A central Walrasian auctioneer is suddenly needed to costlessly coordinate the economy. Technically that can be done if the mathematical model equations can be solved for such an external equilibrium. The above mentioned (Antonov and Trofimov 1993) simulation experiments not only suggest that the CGE model is based on empirically faulty specifications, but also should not be used for empirical quantification, and above all that carrying out policies based on the CGE model are unadvisable.

Four, the entrepreneur of Joseph Schumpeter was for long considered an unnecessary element of economic analysis, and therefore also forgotten in conventional economic analysis, and in economics teaching (Johansson 2004; Rosen 1997: 149), and Baumol (1968) declared that the phenomenon as such, except as a stochastic phenomenon, was incompatible with static general equilibrium, and most probably would continue to be. Not only did any notion of a role for an entrepreneur in economic theory disturb the "beauty" of the GE model, to quote Shackle (1967). It also caused insurmountable mathematical problems to be made compatible with that model.

Not until the realities of the post oil crises global economy had made themselves felt, it was understood that new production structures had to be developed. The question raised at the time was whether Central Government should do the entrepreneurial job as a new type of "Central Innovation Auctioneer". This idea became popular in some industrial economics circles and appeared at the policy level as government sponsored R&D programs and national innovation systems proposals (Freeman 1987; Lundvall 1992 or Nelson 1992, 1993). The alternative to fall back on entrepreneurial incentives and private businesses for recovery, with no intermediate central policy hands involved, took longer to reach the minds of policy makers, but gradually made inroads on the policy agenda.[22] One reason for launching the Micro to Macro modeling project 40 years ago in fact was to explore the rationale for the then common ambition to take typical business decisions up to central policy levels which lacked the competence to pursue (national) innovation systems ambitions. Today, in the wake of a decades long European stagnation after the oil crises of the 1970s, and the miraculous and unexpected entrepreneurial surge in the US economy out of the IT paradox (Solow 1987) during the Internet age from

[21]When Gerard Debreu was awarded the Price in Economics in Memory of Alfred Nobel in 1983 the reason given was that he had helped clarify the role of the invisible hand in GE theory. The invisible hand of Adam Smith, however, had very little to do with static equilibrium.

[22]Cf. Cantner and Pyka (2001) for the change in the German policy mind. Also compare the rapid recovery of the Swedish economy in the "do nothing" policy reference case in Carlsson et al. (2014) when crisis firms were allowed to exit rapidly and workers were reallocated over the efficient model labor markets. The study recognized that the labor market and entrepreneurial incentives in the model were more "efficient" than in reality. It was however also observed, that when the Swedish policy regime was changed in the direction of MOSES model specifications from the mid 1990s, actual Swedish manufacturing growth dramatically shot up to recapture by 2010 more or less the growth the Swedish economy had lost compared to Europe during the subsidy years of the 1970s and the 1980s.

the mid 1990s, this is no longer found surprising. It is furthermore being increasingly understood that central policy makers had little to do with the return of growth.

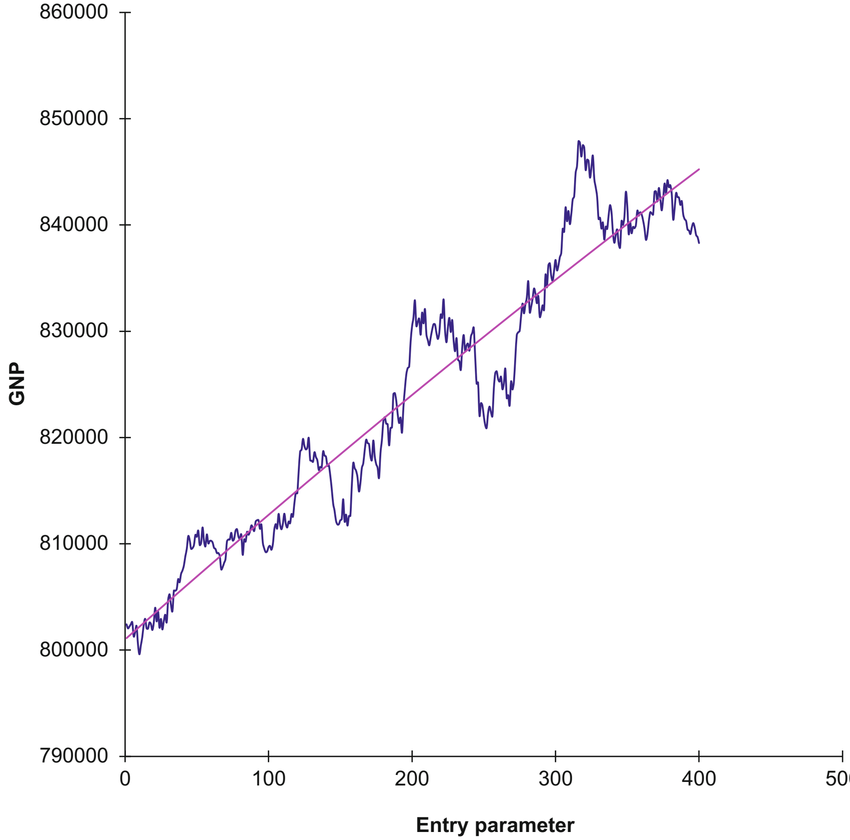
Five, in their Moses based "Tsunami economics" paper Eliasson et al. (2004), show that the *gestation period* needed for the generic new Computing & Communications (C&C) technologies[23] to be commercialized and to show in resumed macro economic growth *may be very long*. Agents in the market (and in Moses) first have to learn and to build the necessary *receiver competence,* and the information accumulated during this learning process and reflected in market transactions did not give off the statistical signals needed for outside econometric analysts to predict the sudden "tsunami" that heralded the emergence of a "New Economy". Due to the complexity of initial conditions, of the learning and incentives guiding entrepreneurial entry in the model, and of the commercialization process in general there is no guarantee that even a very large input of new technology will at all boost economic growth. No New Economy wave in fact occurred in several simulation experiments because of lacking incentives and commercialization competence. So it is fairly safe to conclude that there was no guarantee that the learning and entrepreneurial new business formation required for a successful outcome would at all take place.

Let us therefore finally (and *sixth*) see what happens when we change the time reaction parameters of the endogenous entrepreneurial entry functions in the Micro to Macro model such that the rate of entry is steadily raised. Increased entrepreneurial entry now raises competition in the Micro to Macro model, and forces positive change on incumbent firms through the Schumpeterian Creative Destruction process of Table 1, and increased exit. As can be seen in Figs. 5a, b faster structural change through faster firm turnover lowers the predictability of market prices that in turn raises the business failure rate, and eventually turns the positive macroeconomic effects of entry into reverse. An *optimal growth maximizing rate of firm turnover appears to exists*.

6 Wicksell's Cumulative Process

I began by presenting the Micro to Macro model MOSES as a model approximation of an Experimentally Organized Economy (EOE), which is in turn a synthesis of a number of salient features of Austrian Schumpeterian and Wicksellian/Stockholm School theorizing of the early twentieth century, features that pry our analysis loose from the general equilibrium modeling tradition. The two schools however failed to connect at the time, and then were more or less forgotten for decades (Eliasson

[23]The "fifth generation of computing" and the entry into the Internet era began around the mid 1990s with the commercialization of new integrated computing and communications (C&C) technologies.



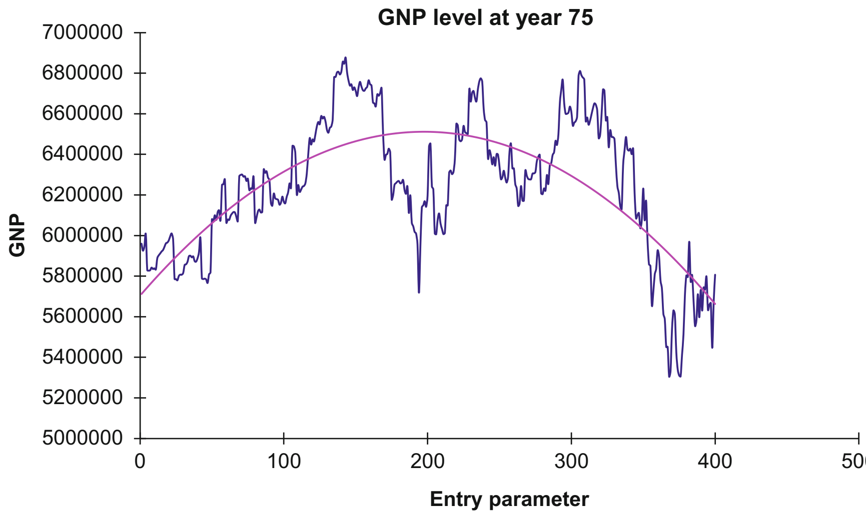


Fig. 5 (**a**) GNP levels at year 15 for different entry rate specifications. (**b**) GNP levels at year 75 for different entry rate specifications

2015). What could therefore be more fitting than to conclude this essay with a stylized MOSES based version of the ultimate dynamics of the Swedish Stockholm School, Wicksell's (1898, 1906) *cumulative process*, which can be theoretically represented within the MOSES economic system.

During his visit to Austria in 1898 Knut Wicksell came in contact with Eugene von Böhm–Bawerk's work in capital theory. Wicksell's use of the concept of marginal capital productivity has made some place him in the neoclassical camp. On the other hand, when Wicksell contrasted the notion of marginal productivity, or the natural rate of return to capital with the money rate of interest, as determined outside the real production system, he quietly did away with the notions of both money as a "veil", Say's Law, and the equilibrium "requirement" that total factor compensations exhaust total production value. When Wicksell finally indicated the possibility of a cumulative inflation process fueled by a "maintained discrepancy" between the money and the real interest rates ($R - i = \varepsilon > 0$. Figure 1b), and a potentially unlimited capacity of the banks to create substitute money (credits), he was no longer in the neoclassical camp (Wicksell 1898: 102ff).

The difference between the natural or real, and the monetary interest rates can be interpreted both as a capital market disequilibrium, and as entrepreneurial rents (the ε Salter curves in Fig. 1b). It was therefore appropriate to ask (above) what would happen if these rents are competed away, to what extent the difference between the natural and the monetary rates could be artificially maintained by policy, and if the quantity theory of money makes sense if the velocity of money, and/or money itself can theoretically escalate out of all proportions. The latter would at least refute the strict version of the quantity theory.[24] Wicksell might have meant that the latter was a phenomenon of the short run, and in the long run the quantitative theory of money should operate as a limit to the cumulative process. At least this is Patinkin's (1952) reading of Wicksell. And Patinkin may in that sense be right when he argues that Wicksell's primary interest does not lie "in describing an *unstable* economy continuously moving away from equilibrium, but in giving a detailed account of how a *stable* economy achieves equilibrium after an initial disturbance". It is however still unclear how that restriction of the quantity theory of money can be imposed on the economy in practice, if credit can be expanded out of all bounds in the short run, and the price system collapses. On this Wicksell (1898: Chap. 7) introduces the interest rate as a regulator of prices.

I have argued above on the basis of MOSES simulations that a capital market with zero rents ($\{\varepsilon\} = 0$) in equilibrium should not at all be a desirable state to aim policies for. Vigorous competition that reigns in the differences but does not eliminate (structural) diversity is desirable. When entrepreneurs react to those rents by investing and/or entering the market (a Kirznerian proposition), they both contribute diversity, force incumbents to improve performance, or exit, and perform a socially desirable endogenous market coordination and balancing act.

[24]Wicksell (1898: 62, 70). Rolf Henriksson has pointed out that Wicksell here in effect presented the quantity theory equation of Irving Fisher.

It is, however, difficult to find documented evidence that Wicksell really attempted to build his "model" such that it should be solvable for an exogenous steady state, which is what Patinkin (1952) suggested. And the Stockholm School economists were rather picking up on the idea of an economy constantly out of equilibrium with ex ante plans and ex post realizations constantly and significantly out of touch, an economy that could never be perfectly coordinated, and that might grow as a consequence of that disequilibrium. [In fact (see Supplement) in my version of an evolutionary economy the notion of out of equilibrium economics does not make sense, since an external equilibrium neither can be defined nor exits]. I have found no argument of Wicksell to the effect that Ex ante plan/Ex post realization differences should be random, something modern Neo Walrasian economists have proposed to accommodate the entrepreneur. The interesting question still is how the difference between the natural and the monetary interest is maintained, and how self coordination takes place in such a "disequilibrium" economic system. An even more interesting question is how the real economy will react to the rate of return and the rate of interest differences. Wicksell in fact unknowingly placed himself in the midst of the currently (2015) hot discussion of the dangers that arise when the financial system is decoupled from the real production system through layers of layers of financial derivatives. The vagueness of Wicksell's own writing therefore leaves room for some relatively free, but interesting interpretations.

Critical for sorting out Wicksell's own position is what he thought about the relationships between the natural interest, or the marginal return to capital, and the monetary interest determined in the monetary system. In his 1898 treatise he took some steps towards bridging the divide between the real and the monetary system, at least in the short run. The Swedish economists also expressed different views on whether Wicksell's notion of a cumulative process was a singular monetary phenomenon, or also embodied an embryo of a growth theory. Ohlin (1937) and Dahmen (1980) suggest the latter, but Landgren (1957, 1960) thinks not. Whatever, Wicksell's own writing can accommodate both interpretations, and includes openings that can be extended into a merge of the real and the monetary system in the form of a simple growth model that can also be derived from MOSES. I say so even though one can find quotes of Wicksell to the opposite. The distinguishing notion is to what extent observed average $\{\varepsilon\} \neq 0$ should be interpreted as investment and growth stimulating entrepreneurial rents, or an inflationary or deflationary monetary disequilibrium (Eliasson 1987a: 95f,b).

Thus, for instance, Gustaf Åkerman (1921, 1923), a brother of Johan Åkerman, in his doctoral dissertation extended Böhm–Bawerk's (1889) theory of capital deepening from circulating capital to fixed capital (Brems 1988) in an attempt to integrate the real and monetary dimensions. On this Wicksell (1923) commented that normally the real economy was held constant when monetary analyses were conducted, and vice versa. Apparently, however, Wicksell thought that this integration could be achieved, but that the "gymnasium mathematics" of Åkerman was not sufficient for that achievement. Many have tried later without succeeding, and the reason is that integrating the real and the monetary dimensions of an economy wide model in a meaningful way takes you out of the confines of the standard calculus of neoclassical equilibrium theory into non linear models that cannot be solved analytically for an external equilibrium.

Today we are not restricted by the traditional mathematical tools. Simulation modeling is a more advanced mathematical tool that makes the integration possible and does not trick the analyst into imposing the restrictions necessary to achieve an analytically tractable equilibrium model along the lines suggested by Patinkin (1952). So we don't have to impose the ceteris paribus clause, holding the rate of return and the rate of growth constant when studying inflation caused by a discrepancy between the monetary and the real rates of interest, and vice versa.

The Micro to Macro model features ignorant firms and entrepreneurs that entertain rate of return expectations on their planned investments that change the allocation of resources and therefore affect economic growth.

A run away cumulative inflation in MOSES is automatically checked by exogenous foreign prices, and rising unemployment, if wages are allowed to run away. Total credits in the system would automatically be checked. But in a closed economy with irresponsible banks, or in the global economy those restrictions may not be there. And if government in an open economy tries to hold back rising unemployment by allowing the currency to be devalued, the self regulation is disconnected.

If devaluation and inflation lower the real monetary interest compared to the real rate of return on new investment, investment and growth may increase and hold back inflation, and also check the cumulative inflation process. Where the balance between real growth and monetary growth ends up is an entirely empirical question. So the "Wicksellian" (1898) cumulative process analysis is quite applicable to the current (2015) situation in the global economy (i e the US, EU and Japan) primed with idling money, ready to be activated.

The Wicksellian proposition could also be reformulated in a different way. Suppose it is desirable to achieve such a balance between the monetary and the market interest rates, and return the economy to some kind of steady state, non inflationary growth. There is a handful of proposed such models (Keynesian and neoclassical) that can be solved for steady states where the real and monetary interest rates are equal and (also) equal to the rate of growth in the economy. Already Cassel (1903) discussed such models, and von Neuman (1945) demonstrated the existence of a neoclassical steady state where the expansion of an economy *under the restriction of no structural change* equaled the interest rate, and no profits above the interest rate could be earned (cf. Smale 1967 on structural stability). The capital market is then in static equilibrium with all entrepreneurial rents competed away. But we have already demonstrated what happens if we attempt to push the MOSES model economy onto such a steady state.

Part of the Wicksellian problem was addressed in Eliasson (1987a: 95f, b). MOSES has a fully integrated monetary and real production system (Eliasson 1985: Chap. IV). Money creation is endogenous, through depositing in, and lending "by the bank". Government can control credit expansion through depository demands on the bank. There is also a financial derivatives module that can boost endogenous credit expansion and further decouple the monetary system from the production system (Taymaz 1999; Eliasson and Taymaz 2001). The exogenous global interest rate and a vector of exogenous global prices for each micro defined market, however, keep MOSES firms from losing control of their wages. That restraint is taken off if policy makers in MOSES allow the currency to depreciate.

Firms pay individually determined loan rates that depend positively on their endogenous debt equity ratios. Local bank lending and depositing rates are determined by supply and demand in financial markets, and link up to the exogenous global interest rate through foreign trade credit transactions as an alternative to direct bank lending. Complete accounting stock flow consistency is created in the initial data base and maintained through the quarterly simulations.

Firms invest (INV) and upgrade their capital equipment and productivities endogenously in response to their expected rates of return ("rents" = ε) over the loan rate:

$$\mathrm{INV} = \mathrm{F}[\mathrm{EXP}(\varepsilon)] \tag{1}$$

$$\varepsilon = \mathrm{R} - \mathrm{i} \tag{2}$$

R is the nominal ("natural") rate of return on capital of the firm, and i is the nominal loan rate of the individual firm (See Fig. 1b). Then:

$$\mathrm{EXP}(\varepsilon) = [\mathrm{EXP}(\mathrm{p}) \cdot \mathrm{EXP}(\mathrm{Q}) - \mathrm{L} \cdot \mathrm{EXP}(\mathrm{w})]/\mathrm{K} - (\mathrm{i} + \rho) \tag{3}$$

where p is the product price of gross product Q. L is labor input, w the wage, and ρ is the rate of depreciation on capital K. EXP is an operator for expectations.

The interest paid by firm j is:

$$\mathrm{i_j} = \mathrm{F}(\phi), \partial \mathrm{F}/\partial \phi \geq 0 \qquad \phi = \mathrm{BW}/\mathrm{SH} \tag{4}$$

where BW stands for debt, and SH for shares or equity on the books (Eliasson 1985: Chap. IV on money in Moses).

Given this a cumulative process experiment on MOSES can be set up:

(A). Endogenize politicians by making the exhange rate against foreign currencies = F(RU), $\partial F/\partial \leq 0$, where RU is the employment rate.
(B). Increase market speeds such that all {ε} → 0.

If unemployment concerns make policy makers give up on currency discipline, inflation in the model economy may escalate out of all proportions. Speeding up markets flattens the {ε} distributions in Fig. 1b and force them close to 0. Self regulation in markets is reduced or decoupled altogether. Cumulative inflation could then occur. It is however theoretically unclear whether the real economy collapses before inflation goes through the roof.

If the initial state of the model economy is such that all {ε} are significantly >0 a balancing act will occur between real economic growth through investment in (1), and inflation through the policy equation (A). Market pricing and predictability are disturbed by inflation and growth reduced. In the “Wicksellian case” with no positive investment and growth response the increased unemployment might start up a cumulative inflation process. Investment and growth stimulus through (1), on the other hand, should raise growth and reduce unemployment and soften a devaluation prone inflationary policy. My point is that in a complete model scenario with integrated monetary and real systems the investment growth response to large positive expected {ε} may be sufficiently large to prevent cumulative inflation from occurring. The latter may be the case Wicksell really considered, but that the Swedish economists failed to agree on.

7 Conclusions on the Economic Modeling of Complexity

This has been my illustrated story of the evolution of the MOSES Micro to Macro model as a merger of Austrian/Schumpeterian and Stockholm School economics. As will be further detailed in the Supplement, a new and highly complex theoretical economic world emerges that can be clearly distinguished from the market clearing general equilibrium tradition, that exhibits all the qualities that we want to associate with evolutionary economics. A helpful instructional result is that an eleven sector computable general equilibrium (CGE) model emerges as a special case when the Micro to Macro model is deprived of its evolutionary features and aggregated to the industry sector level.

The complexity and unpredictability of the evolutionary Moses model economy not only raises uncertainty in the life of explicitly modeled micro agents, who constantly fail to realize their Ex ante plans, but should also alert policy makers, comfortably lodged in the security of fail safe Keynesian or GE thinking, to the high risks of significant policy failure when interfering with the self regulating market mechanisms of the Moses economy. Even seemingly minor policy measures may accidentally cumulate into major events. Policy failure thus is a far more serious problem than the many instances of uncoordinated individual business failures because of the large resources systematically moved around at that level. *The smooth development or macro growth of an evolutionary economic model requires a minimum of unpredictable disorder at the micro market level in the form of business successes and failures.*

The Micro to Macro model, instead of offering guidance for fine tuning economic systems evolution with corrective policies, presents itself as a potentially useful instrument for dynamic cost benefit analyses, especially when further advance has been made on developing credible calibration/estimation methods of the parameters of very complex non linear Micro to Macro selection models. Research investment here should be socially very profitable because of the small resources needed compared to the potentially large social costs of policy makers messing unwittingly with the economy. For the time being the great insight from evolutionary economic modeling is that big Government now appears on the scene as only one of many market agents liable to make serious mistakes. The new morale therefore is for policy makers to be cautious, rather than ambitious.

Supplement

The Evolutionary Nature of the Swedish Micro to Macro Model

I have argued that the theory of an *Experimentally Organized Economy (EOE)*, and its model approximation, the *Micro to Macro model MOSES,* are evolutionary and distinctly different from the standard neoclassical equilibrium model, as well as its empirical application, the Computable General Equilibrium (CGE) model, or for that matter Keynesian & Leontief type sector models. The existence, or non-existence of a traditional exogenous equilibrium is what distinguishes these two theoretical worlds from one another. I have added that that same distinction should also be made the distinguishing feature of evolutionary economics, and that this will cast doubt on the evolutionary nature of the popular (national) innovation systems models. To say that they may not be evolutionary, however, is also close to saying that Schumpeter's (1911) theory, and even more so that his dismal foreboding of 1942, are not evolutionary (Witt 2002).

To motivate such heretic suggestions let me begin with some quotations from literature, and to begin with a sympathizing neoclassical economist from Chicago. Even though "neoclassical economics would be enriched by a more fully articulated view of competition as a selection device, . . .and as a generator of economic change", writes Rosen (1997: 150), disequilibrium analysis is probably not compatible with "the neoclassical scheme". In neoclassical equilibrium, Rosen continues, "there is nothing for entrepreneurs to do", a view voiced already by Baumol (1968). Austrian economics, on the other hand, with entrepreneurial competition as "the main instrument of change" within the economy, therefore "offers a valuable perspective of the economy as an evolutionary process".

Like Rosen, I am perfectly aware that enormous academic effort has been devoted to introducing non equilibrium dynamics into the neoclassical model, without, however, violating its central dictum of the existence of an external equilibrium, and that it may be unfair to those who have tried, to compare with a highly stylized model that they have tried unsuccessfully to abandon. But the preoccupation with static equilibrium with those who still insist not only makes it appropriate, but correct to use the market clearing neoclassical model as a reference bench mark for clarifying the differences to the evolutionary alternative I am going for. Unfortunately this means ripping open the mathematical foundation of market clearing general equilibrium economics. My auxiliary reason, however, is that we now have a well defined mathematical alternative, the Micro to Macro model

Moses that can speak for itself, so we don't have to be overly critical of orthodox economics to make our points.

While Schumpeter has been a standard reference for evolutionary economics, Witt (1993, 2002: 9) takes a polite exception to that view. He requires as a minimum that evolutionary theory be capable of self transformation of the economic system through the "endogenous creation of novelty", or innovation and entrepreneurship. Not much of evolutionary modeling I have seen is however up to that requirement.

In Schumpeter (1911), and even more so in 1942, the innovator, or "creator of novelty" is exogenous and not explained, while the entrepreneur is the endogenous "doer" who turns the exogenous innovations into the kick starter of economic development (Hanusch and Pyka 2007a, b), or perhaps the discoverer of new profit opportunities, which is Kirzner's (1997) perhaps alternative idea of entrepreneurship. But this is not enough to make the creator of novelty endogenous according to Witt, and also Dopfer (2012). By substituting administrative routinization of R&D management for the innovator/entrepreneur, Schumpeter (1942) removed himself even more from the notion of entrepreneurial competition sketched in his 1911 treatise. He has instead inspired the invention of both the central administrative national innovation systems artifacts as policy instruments for the 1990s to help failing markets to allocate R&D spending better, and the "ideas production functions" of New Growth Macro theory, sometimes referred to as "Schumpeterian", very succinctly formulated in Jones and Williams (1998).

The Informational Assumptions About the Unknown

A central premise of evolutionary economics therefore has to be the assumptions made about how unknown to the actors the content of the economic or business opportunities space is. The assumptions made about the state of information in the economy are central for economics (Eliasson 1987a, 1992, 2009). For Carl Menger (1871), and also restated by Rosen (1997: 141), "there is an enormous amount of ignorance in the (economic) system" and "out of the totality of what is known in the economy at large, any single person knows essentially nothing".

Here I venture to add (Eliasson 2005a, 2009) that there is a lot more to learn about in the business opportunities space that none in the economy yet knows about, but may learn about by exploring that unknown totality. By exploring that unknown terrain adventurous innovators and entrepreneurs use their knowledge and experience, significant and critical parts of which they cannot articulate (being *tacit*), to discover new avenues of progress, and not only come up with new ideas. They also, in doing so, expand the opportunities space and prevent it from being fully searched and all opportunities exhausted (The Särimner proposition). In doing so they however also frequently fail to come up with a god design of their business experiment, and *the resources lost through mistaken entrepreneurial ventures become a transactions cost that should be balanced against the gains from the same exploration of the opportunities space* (Eliasson and Eliasson 2005). The economy thus has a capacity to generate new ideas through entrepreneurial ingenuity and discovery.[25] The circumstances favoring, or disfavoring such innovative exploration can be observed and modeled, and the outcome expressed in terms of the productive performance of the innovator/entrepreneur, without characterizing the type of novelty created.

The rate of business failure accelerates if exploration (read entrepreneurial competition) is speeded up (Eliasson 1991a, 2009). Entrepreneurial competition can, however, only occur in markets populated by autonomously behaving business agents. It draws transactions costs in the form of business failure. It has gradually been endogenized in the Moses model in ways to be explained below. The totality of such an endogenous entrepreneurial exploration and selection process must satisfy Witt's general definition of an evolutionary economy. A model of such an evolutionary economy of course soon becomes too complex to be compacted into an equation system that can be solved for a market clearing equilibrium. Coordination of the model economy thus has to be achieved by other means than assuming that a central political chieftain, or Walrasian auctioneer, be around to do the job free of charge (zero transactions cost assumption). We therefore have to think in terms of the emergence of (Lesourne and Orléan 1998) stable systems of coordination as the result of a "collective learning process", and evolutionary self-organizing among agents in markets guided for instance by the constantly changing price and quantity signals from market transactions. Rosen (1997) concludes by paying his respects to the great Austrian economists´ legacy of paying attention to the systems aspects of economic theory,[26] and how "open competition and survival of the fittest work to aggregate highly decentralized knowledge and information into" . . .a "mostly smoothly operating, but rudderless social organization". The Moses model features such self regulating market processes in the form of algorithms that mimic the solution of the model for an external equilibrium that does not exist because of the non linear complexity of the millions of selection processes that make up the Moses model (see Moses code in Eliasson 1976b: 193ff, 1978a: 175ff). Obviously such a convergence process (it normally converges in the short run!) won't be perfectly stable, because it also changes the structures of the economy that

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[25]In neoclassical growth theory R&D is the resource that goes into that creative activity, but since failed business experiments, that neoclassical theory fails to recognize, appear as unpredictable transactions costs in the Micro to Macro model, the model economy also fails to come to rest in static equilibrium.

[26]As a matter of curiosity, Blaug (1962) failed to give Schumpeter a chapter of his own, because (Op cit, p. 416) he "failed in any way to provide either a systematic theory or classification of innovations or an analysis of the manner in which innovating "entrepreneurs"—the source of all dynamic change in the Schumpeterian system—appear on the historical scene. And so economists continued by and large to abstract from technical progress." The Austrian chapter is about Böhm-Bawerk's theory of interest and roundabout production, where also Wicksell appears (in his critique of Böhm-Bawerk) as a neoclassical economist. Wicksell, however, appears again in the chapter on neoclassical monetary theory, where his cumulative process, created by a discrepancy between the market rate of interest and the expected yield on investment, is mentioned as a curiosity. Menger appears as one of the three creators of marginalism. Von Hayek gets footnote attention. But Ex ante investment plan Ex post differences with reference to Wicksell, Myrdal and

in turn affects the predictive information content of price signals negatively, and therefore subjects the analyst to frequent surprise experiences.

Hence, the policy maker, or his economic adviser, will be as prone to significant misunderstanding and policy failure, as are all other market agents to business failure. Due to gross ignorance on the part of the central policy auctioneer of the Moses model he therefore cannot solve the neo classical coordination problem analytically. And the macro consequences of failed policy action are potentially far more serious than individual business mistakes that are balanced by business successes, because of the large resources the policy maker can move around. *Evolutionary economics*, as I see it in terms of the Moses model, *makes the central policy maker into only one of the many other failure prone market agents* (Eliasson 1991a).

So the distinguishing features between the neoclassical model and evolutionary economics are (1) the existence, or *non existence, of an external equilibrium* for which the model can be solved,[27] (2) the necessity of modeling coordination through *competition driven self coordination in markets* among autonomous micro agents, and (3) to model the endogenous creation of eternal entrepreneurial competition. So it remains to explain how perpetual entrepreneurial competition through endogenous novelty creation can be maintained indefinitely in the Moses economy.

Agents Forced by Competition to Venture into the Unknown

The business actor can always act on more knowledge than s/he can articulate. Such *tacit knowledge* guides the firm when exploring the unknown segments of the opportunities space, or when being forced to act prematurely to avoid being overtaken by competitors acting similarly (Eliasson 1992, 2005a: 435f, 439f). During that exploration agents upgrade their human capital (Ballot and Taymaz 1998) and spill parts of that same human capital to other actors to imitate or improve upon.

As a consequence of entrepreneurial competition the Micro Macro model economy features the evolution of *endogenous populations of firms*, most importantly through firm entry, and forced exit. Such endogenous structural change first of all affects the reliability of market price signals negatively as predictors of future prices, and raises market uncertainty. Competition furthermore forces firms to innovate in order not to be overrun by innovative competitors, and all constantly risk failure because they have to act long before they have satisfactorily understood

Lindahl are commented upon in the context of Keynes' investment and savings schedules. Knowledge capital and information economics are hardly mentioned. So most of what my paper has been about had no place in the economic doctrines half a century ago.

[27] As a consequence evolutionary models should not be referred to as disequilibrium analysis, since the standard neoclassical equilibrium cannot be defined in terms of such models.

their business situations, and because competitors may turn out more successful. The rationality of this behavior is that rational *actors in an EOE understand that they are grossly ignorant of circumstances that may eventually threaten their survival*. They are "boundedly rational" to use Herbert Simon's term.[28] This state of constant *market anxiety* leaves little margin for rest, and prevails for ever, if not reduced by regulation or monopoly formation. An important *part of explicit evolutionary modeling therefore is to characterize what information/knowledge firms base their expectations and plans on, or how ignorant they are when they make their decisions*.

Firms innovate by exploring the business opportunities space within which all economic action takes place, by imitating, learning and recombining technologies. But those innovations are also added to the opportunities space for other firms to imitate, learn and recombine again. The opportunities space thus increases from being explored by agents that are forced by competition to explore its interior. This Särimner proposition prevents the evolutionary Micro to Macro model from collapsing into its special case, the full information state of a general equilibrium model. In the case of the Micro to Macro model this state obtains when all evolutionary characteristics have been removed and agents have been aggregated to sector levels, namely a Keynesian–Leontief, or a CGE sector model. As explained in the main text a stylized version of the Särimner proposition (Eliasson 1987a: 29, 1991a, 1992, 2009) has been in the Micro to Macro model since Ballot and Taymaz (1997, 1998), and the two are currently working on an improved specification. As a consequence the Moses model will feature a Micro to Macro market based model economy that evolves within, but constantly trails the endogenously evolving business opportunities space.

Endogenous Market Self Coordination Without a Central Policy Auctioneer

The unpredictable endogenous evolution of the Moses model economy is moved by millions of entrepreneurial decisions and guided by prices and quantities determined in markets, all being based on a wide variety of individual and endogenously evolving circumstances. The evolution of the Moses economy may take very different directions depending on these circumstances, and the reliability of prices as predictors of future prices is critical for how markets coordinate that evolution. Things may therefore temporarily, sometimes permanently, go all wrong, and the economy collapses, but normally the model economy follows a cyclical well behaved growth path well underneath the upper bounds of the opportunities space, and extreme systems movements are endogenously corrected through

[28] But they are also grossly ignorant, not only marginally uninformed, which is as far as neoclassical asymmetric information theorist can go without coming up with problems.

micro based demand and supply decisions in markets.[29] Since the economy is bounded from above, excessive movements in one direction tend to be reversed by corrective supply and demand decisions in markets (the Le Chatelier principle). Well behaved macro behavior, however, is normally matched by a corresponding disorder at the micro level, and vice versa. The social and political capacity of a nation to cope with such micro market disorder and unpredictability can be said to also define its capacity to become, and to continue to be a wealthy and growing economy (Eliasson 1983, 1984, 1992).

Statistical learning theory has taught us that the requirements for reliable price signaling are strict (Lindh et al. 1993). Economic transactions only emit reliable and interpretable price signals if the (model) economy features a (sufficiently) stable endogenous quantity structure (the fundamentals) to be revealed by the price signals (Eliasson 2005a: 451).[30] If structures change because of firms´ production and investment decisions the reliability of price signals are negatively affected with a feed back on quantities/structures, and so on. It is no coincidence that both von Neuman (1945) and Smale (1967) formulated very elegant equilibrium growth models under the assumption of no structural change. That mathematical elegance disappears when structures, as in Moses, change endogenously in response to firms´ price expectations and investment decisions. You then also learn that growth cannot occur without a concomitant endogenous structural change, and that perfect coordination onto an equilibrium trajectory is impossible.

Moses as an Evolutionary Design

I will therefore clarify the evolutionary origin of the Micro to Macro model by directly relating it to its two inspirational sources (the Austrian/Schumpeter and the Swedish Stockholm School tradition), and to recognize the empirical tradition of the Carnegie Mellon School of Herbert Simon and followers. When explicitly modeling Micro to Macro, the information and knowledge agents base their individual expectations and plans on, and how they do it, have to be specified.

To begin with the evolutionary nature of the Micro Macro model, as conceived already in 1974, was the consequence of the assumptions made, not originating in an ambition to do evolutionary modeling. The necessity to take macro economics down to its micro economic foundations was singularly overwhelming after my field study (1976a). That field study also suggested that I should stay away from the

[29]Recovery may however take a long time. Cf. Eliasson (1983: 315ff, 1984) where the Moses economy collapses after being tripped by a small micro event, that created a ripple of downstream economic systems reactions, cascade effects of exactly the same kind as those modeled by Acemoglu et al. (2012) who challenged Lucas (1977), and several other besserwissers, who had claimed that such microeconomic shocks would average out and leave only small ripples at the systems macro level. That was clearly wrong as we had already understood.

[30]In static equilibrium mathematical duality prevails, and prices map exactly into quantities and vice versa.

limitations of neoclassical doctrine, as evidenced in Fisher (1972), and later in Weintraub (1979). To explain the dynamics of an economic system populated by autonomously deciding and behaving agents in product, labor and financial markets, we had to know what these agents actually knew, and according to what rules they were preparing and making their decisions (Eliasson 1976a, 2005a). Quite in line with the Stockholm School ideas, firms made up ex ante plans, and responded to their realizations ex post when confronted with the plans of other agents in markets, all staged on an evolving quarterly format.

The empirical ambition made it necessary to model observable Micro agents that made decisions according to information and rules that could also be observed., An advantage of that approach was that the *Moses firm model then could be related directly to the internal statistical information systems of firms that could be directly accessed through a statistical survey*, the Planning Survey of the Federation of Swedish Industries (see below).

To meaningfully theorize and model competition driven selection among agents in markets unavoidably takes you into non linear mathematics and initial state and path dependent empirical models. To study the evolution of such models you have to specify (measure) the initial state of the economy and be empirical (see below).

The next step was to model how firms´ behavioral rules observed appeared in their supply decisions and competition strategies in markets, and how they contributed to a converging price and quantity determining market process from period to period (Eliasson 1976b: 68ff, 185ff; Albrecht et al. 1989: 155ff, 314ff). If I may borrow some terms from evolutionary game theory (Weibull 1995, also see Ballot and Taymaz 1998: 312), without therefore implying that the evolutionary process moves from one price quantity equilibrium to another, the variety necessary for evolutionary economic systems stability is achieved by investment and R&D based innovative improvements in firm performance ("mutations"), while innovative firm competition, inter alia through new firm entry enforces the selection among agents ("replicator dynamics"[31]) that raises the performance of the entire economic system. One experience from early model work (see further below) is that seemingly insignificant events may have a major impact on the long run development of the entire economic systems model.

Since the ex ante plans made up and executed by agents are both highly varied, inconsistent, and, as a consequence, rarely well tuned to the emerging business environment,[32] plan realization differences are large (but not stochastic), *economic mistakes frequent* and normal, and the model highly non linear and too complex to be solvable for an external equilibrium that does not exist even as an approximation. In fact, when speeding up market arbitrage in the model through

[31]In the first model version selection among firms is enforced through competition in markets, forcing upgrading of performance or exit through the Schumpeterian type creative destruction process (in Table 1 in the main text). In later versions various functions of the competence bloc theory of the main text that governs selection and commercialization of technologies within firms, or in markets have been introduced (e.g. Ballot et al. 2006).

[32]An environment largely made up of all competing agents, and therefore also endogenous.

exogenous policy interference, forcing it closer to an approximate external market clearing equilibrium,[33] the economic system eventually collapsed (Eliasson 1984, 1991a). This non existence of an external equilibrium, and a preserved micro heterogeneity (through innovation) should therefore be considered both a prerequisite for preserved economic systems stability, and a typical characteristic of an evolutionary model (at least as I define it), and one consequence of the Wicksellian ex ante and ex post based theorizing of the Swedish Stockholm School economists. These ideas were also an early source of inspiration of mine both in my doctorate thesis (1967, 1969), my field survey of business economic planning (1976a), and when designing the Micro to Macro model (1976b, 1977), ideas that were unfortunately abandoned by later Swedish economists in favor of the then popular general equilibrium model (Eliasson 2015).

So both on empirical and theoretical grounds I make the Stockholm School notion of ex ante agent plans and ex post realizations when confronted in markets, a distinguishing feature of evolutionary economics. There boundedly rational ("ignorant") agents act on intuition, and their successes and failures in markets feed back to influence next period decisions, and so on ad infinitum. With millions of such decision being made each quarter it should be no surprise that the ensuing quite delicate dynamic balancing act may go wrong now and then. To the contrary it is surprising how rarely it happens both in MOSES simulation and in reality. The advantage with the MOSES model is that you can then trace the reason for the occurrence. That notion of feed back economic systems stability, however, does not come out clearly in the many characterizations of evolutionary economics in literature, not all of which have an explicit micro market foundation. I will therefore present my version, and to the extent possible relate that version to some chosen evolutionary economics papers.)

What Does a Selection of Literary Sources Have to Say On This?

While selection is practically always referred to in economic literature called evolutionary, the roles of the market and autonomously behaving agents, and the firms intermediating that selection is conspicuously absent. Here Schumpeter (1942) may be partly to blame in that he envisioned the possibility of an invincible firm that eliminated other firms in the market (including the market) through

[33]Technically the market arbitrage mimics the solving of the highly non linear Moses model for such an equilibrium. Since such an equilibrium point or trajectory does not exist the solution process starts to diverge dramatically when the model economy comes too close to an approximate capital market clearing equilibrium. Prices and quantities are registered along the way per period. If forced to the extreme this solution or competition process eventually forces the economic system to collapse when diversity has been dangerously reduced, rates of return have become fairly equal across the firm population and close to the interest rate, and in addition, the number of firms has been reduced through exit such that market processes can no longer be meaningfully supported (Eliasson 1984).

superior routine R&D management, an idea that recurs in the policy model both of a (national) innovation system, that is often called evolutionary, and in neoclassical new growth theory models, such as Jones and Williams (1998), ideas that to my mind contradict the concept of evolutionary economics.

Selection moved by market competition among satisfying firms is an important element in Winter's (1964, 1971) early evolutionary modeling. The role of the market in economic selection has however faded considerably in Nelson and Winter (1982),[34] who relies more on Schumpeter (1942) than Schumpeter (1911), show a preference for premarket or non market selection, and in the end come up with typical neoclassical arguments of under or overinvestment in R&D and arguments against leaving the allocation of industrial R&D entirely in the hand of "profit-seeking firms and competitive markets" (Op cit, p. 390ff). These are arguments for central policy interference to correct market failure, arguments that soon thereafter show up in the national innovation systems literature aimed at replacing prostrate centralist Keynesian demand policy with centralist policies of the "picking winners" type. I mention this since the Nelson and Winter (1982) volume is generally referred to as a herald of evolutionary modeling. Evolutionary modeling, as I see it, should not only underline the equally, and far more serious high risk of policy failure when Governments doped by Keynesian or neoclassical policy advice ambitiously interfere with the self regulatory market mechanisms of a complex economic system they do not understand. The latter is a possibility not mentioned in the Nelson & Winter volume, that is far more socially costly than individual business failure. "Overspending on certain types of R&D as well as underspending on others" (op cit, p. 390), furthermore, is a natural feature of experimental (evolutionary) market selection by ignorant actors, and something one can only pass judgment on Ex post, and that the market still understands best Ex ante. So there remains the reasonable neoclassical argument of underinvestment in public goods type infrastructures with large positive externalities. But that conclusion is classical neoclassical.

Unfortunately Nelson and Winter (1982) has become an intermediate step in the transfer of the Darwinian market selection of Winter (1964) to the policy oriented innovation systems of Freeman (1987), Lundvall (1992) and Nelson (1992), which appear as central administrative business systems to correct the failure of markets to allocate R&D spending "efficiently" and in sufficient volume. Typical neoclassical arguments are offered in support of such policies, and the role of entrepreneurial competition is downplayed, if at all mentioned.

I therefore see a need to repeat the entrepreneurial competition argument that Rosen (1997) makes the distinguishing feature, and therefore minimum requirement of evolutionary economics, and that such competition requires a micro based market representation to make sense. Hence evolutionary models will have to be agent or firm (micro) based, and feature *endogenously evolving populations of agents (firms) through new business creations, their life and final death (exit)*, or

[34] That is so even though Winter (1964, 1971) appear as Chap. 6 in condensed form.

for simplicity the role of endogenous new firm creation, growth and exit in economy wide systems behavior. Moses then becomes an excellent illustration of such a model since it featured endogenous exit and populations of agents from the beginning (Eliasson 1976b), and definitely since Taymaz (1991a:59ff), when also firm entry was endogenized, as well as explicit market intermediation and selection among those firms.[35]

This places emphasis on the nature and the role of the entrepreneur in economic evolution and whether Schumpeter's exogenous innovator/entrepreneur qualifies Schumpeter (1911) as evolutionary theory. Witt's argument, and also that of Dopfer (2012), is that Schumpeter fails to explain the creation of new economic ideas, and only how the entrepreneur carries out those ideas, or to use my term, *commercializes the innovations*. My inclination is to take exception to that position. New ideas are unique by definition, and their nature cannot be explained Ex ante by theory, only observed Ex post.

Bo Carlsson (1995) and Carlsson and Stankiewicz (1991) presented their technological innovation system as an alternative to the Freeman, Lundvall and Nelson innovation system. Theirs is a design to show how innovation supply is stimulated, created and selected without carrying on to a policy model aimed at controlling the outcomes. Even though they mention the presence of an entrepreneur as a facilitator, the ambition is to improve the selection of technically defined innovations, for instance how they appear in Table 2. In that sense they answer up to Witt's (2002) creation of novelty in designing the complex of institutional circumstances explaining novelty without detailing the nature of that novelty. Theirs can also be seen as a more sophisticated institutionally specified micro version of the R&D based macro innovation ideas production functions you find in neoclassical growth theory (e.g. in Jones and Williams 1998).

Neo-Schumpeterian Complexity Economics

Since the above characteristics all appear in the Micro to Macro model I will finally try to frame my characterization of this model as evolutionary in the terminology of Hanusch & Pyka's (2007a, b) identification of the five intellectual sources of Neo-Schumpeterian economics; (1) the Schumpeterian (1911) exogenous entrepreneur, (2) the path dependencies and irreversibilities of evolutionary economics (Dopfer 2005), (3) the interactions and feedbacks of complexity economics (Kirman 1989; Frenken 2006; Fontana 2010; Allen 2014), (4) the endogenous innovation and competition process that both drives and regulates the entire economic system, including the learning that expands the opportunities space of the economy (Eliasson 1992, 2009), and finally (5) the notion of an evolutionary economy as a dynamic economic system that in my version cannot be controlled, only influenced,

[35]Introducing endogenous entry in an economy wide model is very difficult. Dosi et al. (2013) have used the Dasgupta and Stiglitz (1981) modeling trick of making entry equal to exit.

by policy, and not rarely for the worse. All five dimensions figure explicitly in MOSES. Hanusch & Pyka's general concept is Neo Schumpeterian economics, so the MOSES model becomes both Neo Schumpeterian and evolutionary and the complexity dimension should be obvious from what has already been said.

Irreversible feed back dynamics of historic selection is one economically relevant property of the micro based Experimentally Organized Economy the origin of which can be traced to the merger of Wicksellian, Schumpeterian and Smithian economics (Eliasson 1992) that you don't find in the received CGE model. I demonstrated in the main text that the static standard CGE model, falls out as a special case of MOSES when all the dynamics of firm behavior, market processes and competition have been removed. Similarly, a stylized version of the Wicksellian Cumulative Process has been shown in Sect. 6 to be embodied in the Micro to Macro model.

A non linear selection—based and initial state—and path dependent model by definition has to be micro based, and features endogenous populations of firms (structures) and complicated irreversible trajectories. As a rule it cannot be solved for an external equilibrium trajectory, the non existence of such an external equilibrium therefore also becomes a distinguishing feature of the evolutionary model.

The other side of the same property is that the evolution of the economy follows different paths depending on initial conditions and the composition of price and quantity feed backs in the economy (path dependency). This makes the number of possible outcomes extremely large, the totality immensely complex and the future utterly unpredictable. This complexity is cumulated as the economy progresses through history and new initial conditions are constantly redetermined by the model from period to period. This is again a typical characteristic of non linear economic systems, and notably micro based economic systems, moved by selection in firm populations characterized by endogenously sustained variety. Since initial conditions cannot be determined with infinite exactitude, neither can the evolutionary orbit (or future trajectory) of the model population of firms (Puu 1989: 5). We therefore experience phases of "chaos" when seemingly small events may cumulate historically into major macro economic events. Future evolutionary outcomes hence become unpredictable and optimization therefore not a rational mode of behavior, something Herbert Simon understood decades ago. Since this is a property of both evolutionary and complexity economics, these two intellectual sources of neo Schumpeterian economics emphasized by Hanusch and Pyka (2007a, b) come together nicely.

Selection furthermore can only occur among diverse, non representative firms, and that diversity has to be sustained over time for economic systems stability. Consequently, the key notion in evolutionary economics, both in its verbal form of an EOE, and its mathematical model approximation MOSES, becomes embodied in the Särimner proposition. As an assumption it theoretically prevents the evolutionary model from collapsing into the full information state of a static general equilibrium model. Empirically, however, looking at the economic world around us, the evidence is overwhelmingly in favor of that same proposition, and that it describes a state of the world economic that must have been true since the Stone age.

Furthermore, and already indicated in Hanusch and Pyka (2007a, b: 276), the evolutionary model therefore also has to feature uncertainty as distinct from calculable risks (Eliasson 1985: 315ff), and now and then exhibit "potential surprises" (Shackle 1949).

The third (or rather first) intellectual source of Neo Schumpeterian economics of Hanusch and Pyka (2007a, b) is the exogenous Schumpeterian innovator/entrepreneur who disrupts the "regular circular flow" of Schumpeterian economics, and "kicks off economic development".

One problem is to verbalize the evolutionary concept, which I do in terms of the theory of an Experimentally Organized Economy (EOE). The difficult problem, however, is to mathematically formalize the full evolutionary model, including the endogenous entrepreneurs that keep the economy on the move through endogenous innovation driven competition of Schumpeterian Creative Destruction, or the dynamic forces that both create and preserve diversity of the evolving firm population over historic time. During this economic systems evolution both the cyclical balancing of macroeconomic stability and microeconomic "disorder", and the possibility of systems reversals (the Le Chatelier principle) present the "policy maker" of the MOSES model economy with difficult, but interesting tasks, that s/he cannot study, and practice on the received economic policy model. I have referred to *surprise economics* in the main text as one property of the MOSES model we have learned about from the beginning of modelling work (Eliasson 1983: 272, 1984), as well as the initial state and path dependency typical of non linear models that makes evolutionary selection driven models unavoidably empirical, and model specification, database quality and parameter estimation/calibration a critical part of economic analysis.

Path dependency arises in initial state dependent models with periodic feed back and updating of the initial state, as in MOSES. With no feed back path and initial state dependency are the same thing. I think this would be Paul David's (who came up with the term) characterization, but I am not sure. It relates to so called non ergodic models with a memory, that loosely speaking end up differently depending upon where they start and which path they take. This property has been referred to in the criticism levied against the "ahistorical" nature of neoclassical economics. David (2002: 15) argues the case for path dependent and non ergodic models to make economics the "historic social science that economics should become". For the record, MOSES is both path dependent and probably non ergodic and historical in that sense, and in addition features the interesting historical systems property that seemingly minor occurrencies with time may cumulate into major historical events.

It has long been known that exogenous disturbances can generate long waves of economic development (growth cycles) in non linear models, but then a constant exogenous input is needed to generate sustained economic growth. To become truly evolutionary that same entrepreneurial input has to be endogenized.

The Endogenous Entrepreneur in the EOE, in MOSES and in Literature

MOSES achieves that endogenization in a straighforward way, but it can be verbalized in a much more sophisticated and easy to understand fashion for the theory of the Experimentally Organized Economy (EOE). I therefore begin with the latter. Three assumptions are needed to endogenize the Schumpeterian (1911) innovator/entrepreneur: (1) *innovative competition* by endogenous entrepreneurs forces all agents to innovate, (2) *learning* when the entrepreneurs are forced (by competition) to explore the (business) opportunities space to come up with innovative ideas, (3) such that *the opportunities space expands from being explored*, when agents learn from each other (the spillover property of a competence bloc). That expansion is likely to be faster (an empirical question) than its content is being searched and exhausted (The Särimner proposition). The first information paradox of economics therefore is that we are becoming increasingly ignorant of all that we can know about.[36] Under those assumptions each individual agent in the market will be constantly challenged by a sufficient number of incumbent and new actors to be forced to successfully innovate to avoid being competed out of business (exit), and that this situation of constant unrest and market anxiety prevails for ever, if not prevented by regulation and monopoly formation. Then new firms will be induced to enter markets where they see Ex ante profit opportunities (This is the specification we have of endogenous entry in MOSES since Taymaz 1991a:59ff). Together a sufficient number of incumbent and new agents will then constantly challenge each agent in the market and force it to act innovatively not to be competed out of business, which it is if it fails on the innovation side, and agents constantly do. In this way endogenous entrepreneurial competition keeps the Schumpeterian creative destruction process (in Table 1) going, and endogenous macro economic growth is achieved that constantly lags the faster expanding opportunities space. The latter (3) finally signifies the necessary requirement to prevent the model from collapsing into a static general equilibrium model.

This is a verbal rendering of how the evolutionary growth process takes place both in an EOE and in MOSES. I am not sure this satisfies Witt's (2002) criterion for endogenous creation of novelty or innovation. The theory of an EOE and Moses offer no endogenous explanation of the outcome of the innovation process, except that it creates improved technology in firms in terms of the specification of technology improvement in the firm model, and that innovations that do not succeed are

[36]See Eliasson (1990b: 34f, 46f, 1992, 1996a: 27f).The second information paradox states that because of the increased share of difficult to measure qualities in economic inputs and outputs we are increasingly losing statistical control of what is going on in the economy. The third information paradox combines the first two and states that due to the immense complexity of the economic system gross ignorance prevails at all levels. In order to act and make necessary decisions all actors have to fall back on simplistic personal interpretation models, or ask information consultants with similar personal interpretation models for advice. I believe this last notion of a "misinformation society" is very Mengerian/Austrian in spirit.

eventually forced to exit (selection). *The conditions under which the market competition game forces innovation (novelty) to be created are* however *explicitly modeled*. This will have to satisfy Witt's requirement, since it is by definition not possible to model the creation of something previously entirely unknown.

Menger, despite being one of the fathers of what later became mathematical economics and the static GE model, was not enthusiastic of quantification and mathematization of economic theory. Similarly Dopfer et al. (2004) emphasize the intellectually limiting nature of neoclassical economic analysis, or what they call *algebraicism*. Even though Dopfer et al. (2004) are right, this still does not make it necessary to take exception to algebraicism, only to empirically incorrect specifications, such as those of the static general equilibrium (GE) model. Quantification does not necessarily limit intellectual reasoning, and being empirical should not be a bad word in economics. And we have put great effort into using measurable concepts and empirically correct specifications in the Micro to Macro model MOSES. Most evolutionary models I have seen are however "theoretical" in the sense that they quantify a stylized evolutionary process of a synthetic economy, or (more commonly) a subsystem of an economy. That may limit or distort the empirical understanding of the evolutionary nature of a real economy.

Quite often you also want to quantify the economy—wide consequences of some micro phenomena that stretch over historic time, for instance the macroeconomic consequences of the large Swedish industrial subsidy program in the 1970s in Carlsson (1983a, b), calculations revisited in Carlsson et al. (2014): What did it cost Swedish society in terms of lost output to temporarily save a few jobs on the defunct Swedish shipyards? One may also want to know the "invisible" civilian productivity benefits of large military procurement projects to balance the measured, and very "visible" costs incurred (Eliasson 2017). The standard model used for such cost benefit analyses is the static CGE model, which is unsuitable for such analyses. It is normally sector-based which makes quantification of the initial micro event awkward. It is static, and lacks feed backs while the consequences of the micro, say policy, event progresses through a real non linear selection based economy. The CGE model is however often economy wide, which is good, and a property needed for such analyses.

Post-script on Evolutionary Economics

From the beginning the Micro Modeling project was set up to be empirical and possible to relate quantitatively to a real economy. (This may have been the wrong strategy academically because academics familiar with non linear selection based economic modeling, read evolutionary theory, regarded Moses as a specific country model. Scientifically it has however been the right strategy to pursue. It has forced us close to the limits of quantitative modeling and made us realize that a relevant Micro to Macro theory of an economy, despite the difficulties of the three information paradoxes, has to be empirical to make sense.) Hence great effort was spent on measuring the initial state of the Swedish economy through a firm survey of the entire manufacturing sector. Since dynamics is the essence of an evolutionary model we did our best to estimate or calibrate the model parameters (Eliasson and Olavi 1978; Klevmarken (1978) and above all Taymaz 1991b, 1993). The economy wide dimension was obtained by placing four firm based markets of manufacturing industry in the midst of an eleven sector Keynesian–Leontief model enclosed in the markets of a complete financial system. The macro Keynesian–Leontief sector model part is, however, primarily used to scale simulations up to the national accounts level of the particular economy chosen, to make calibration of parameters against official statistical data, and quantification of the economy wide consequences of particular occurrencies possible. The static nature of that economy wide frame also makes it ideal as a national accounting measurement frame for the entire model economy, within which the evolutionary Micro Macro model growth engine Moses is an integral part.

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