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Modelling the Experimentally Organized Economy (II)

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Abstract The Swedish micro to macro model MOSES is presented in terms of original technical publications and early empirical studies. It is shown how autonomous firms form expectations, make up plans, set prices, and revise plans after having been confronted with other firms' plans in product, labor, and financial markets, and how all market agents together *endogenously self-coordinate the macro economy,* and keep it evolving over time. Agents *learn* from their expectational mistakes to improve next period anticipations and plans. Combined with endogenous *Schumpeterian entrepreneurs* that enter markets unexpectedly, this unique *Stockholm School feature* confers radically new dynamic properties to the macro economy. Entrepreneurial entry not only subjects the model economy to a constantly ongoing Creative Destruction process (endogenous structural change), but also keeps incumbent firms under constant competitive pressure that forces them to *innovate preemptively*, not to be competed out of the market (*exit*), and thus propels the economy forward in time, leaving in its wake an endogenous population of firms. A master version of the MOSES model has been calibrated to represent a *Sweden like advanced industrial economy*. The selection of publications also demonstrates how the *modular design* of the model has been gradually expanded, around its original dynamic market module, to become a model approximation of what I call an *Experimentally Organized Economy* (EOE) in which decisions of *boundedly rational* agents *become economic experiments to be tested in markets*. In fact, the model economy can even be used by boundedly rational policy makers, who should not conduct experiments, but fortunately can learn about the limits of their policy ambitions by practicing on the MOSES model.

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The modeling project of this Anthology, initiated in the mid 1970s, had great empirical ambitions and the aim to eventually make macro-economic modelling redundant. The Model of the Swedish Economic System (read MOSES) is still alive and empirically implemented, with somewhat moderated ambitions, however, but prepared for further extensions (Section 6). Empirical economy wide modelling is resource demanding, and the model needed a solid theoretical foundation to explain its unfamiliar systems behavior. The nature and full scale of all this was of course not fully appreciated at the start. The publications in this anthology, including references to easily available journal articles, have therefore been selected to give the MOSES model both a defined place in the theoretical environment of received economic doctrines, and an account of the practical hurdles that have had to be overcome during its now (2024) fifty-year history to keep the model alive and in working condition. The publications also demonstrate how the micro simulation method, using numerical computer simulation mathematics, can both help advance general economic theorizing, and make quantitative micro market-based economy wide analysis possible, in effect achieving a natural integration of theory and empirical method. An extra effort has been devoted to explaining how endogenous and resource using markets self-organize the economy, when processing the information and exercising the competition that govern the allocation of resources that propels the model economy over the longer term, together being a unique signum of the MOSES modelling method. I show how the integration of at least six familiar models associated with Keynes, Leontief, Marshall, Schumpeter, Simon and the

Stockholm School economists, including Knut Wicksell, helps minimize the partiality predicament of economic theorizing, and clarify that economics is not a business for specialists. Sections 1 and 2 are therefore a theoretical introduction devoted to the study, in selected publications, of the properties of the model economy, or for short, establishing both the empirical relevance and the theoretical foundation of the artificial reality of the MOSES model economy.

The MOSES model has been designed bottom up based on expectations and business plan formation and decision making as observed in my interviews with almost a hundred European and American firms in ***Eliasson (1976a)***, and empirically implemented on micro data from a special survey, the Planning Survey of the Federation of Swedish Industries, all scaled up micro to macro and stock flow consistently (SFC) to Swedish National Accounts (NA) level. All incomes generated by production agents are filtered back as Keynesian demand after taxes and income transfers through a household demand system. The core manufacturing model has been encased in a complete eleven sector Keynesian- Leontief sector model.

Since clarifying the role of production agents and markets in fashioning the dynamics of a macro economy was an early ambition, we have learned, as the complexity of the model economy has increased, that even being fully informed about its underlying code, such a model economy is not a controllable economic system.

On the contrary, *heterogeneous agents with price setting autonomy and different agendas, guided by expected prices, together frequently thwart policy makers' ambitions*. Consequently, *increased market flexibility often comes out as preferred policy to regulation and parameter manipulation based on forecasts by boundedly rational policy makers*. Such comparisons are of course not possible if the model has no micro agents, no explicit markets, no Stockholm School feed backs of mistaken expectations to learn from, the latter deficiencies being typical characteristics of the two main fields of economic modeling - macro and general equilibrium economics - and, as it seems, also the emerging field of evolutionary modeling. To rectify this deficiency has provided sufficient incentives for keeping this project alive for fifty years (2024). For this the micro simulation method, including agent-based modeling, has been the right instrumentation, a potential that to my mind has so far not been taken full advantage of (***Ballot et al., 2015***; ***Pyka and Fagiolo, 2007***). Already ***Koopmans (1957)*** predicted that computer based simulation mathematics would in the future restore the numerical example as a respectale tool for general economc analys. On this I add that it will above all free the economist of the inhibiting restriction associated with orthodox modelling.We conjecture that a real economy must be even more of a challenge for ambitious policy makers, and that *the collective knowledge embodied in market agents and transformed into market action means that increased market flexibility often comes out as preferred policy*. The policy maker can in fact profitably learn about the limits of his ambitions, and how to work with, instead of against markets, by practicing on the MOSES model (***Eliasson, 1991a***; ***Eliasson and Taymaz, 1992***).

After having validated the empirical foundation of the MOSES model as a *Sweden like industrial economy* (in Section 3), a series of empirical applications are summarized (in Section 4) ranging from economy wide social cost benefit studies of major policy interventions, to being used as a policy trainer to minimize the incidence of policy mistakes or negative side effects, or for that matter, to study (in the 1980s at the CEMI research institute in Moscow) how to transfer a centrally planned economy to a market economy. The latter general use of the MOSES model as *cognitive support* for effective policy design is argued in section 5. In the concluding section 6 ideas about further expansions of the model, including its empirical use, are discussed.

Dynamic market based initial state dependent economy wide modelling confronts the economist with difficult estimation problems many of which remain to be solved (***Richiardi, 2017***). The MOSES economy is however founded on *an empirically well-grounded bottom up prior design and high quality initial state micro data tailored to the specification of the model* to allow simulation results to be *referred to a Sweden like advanced industrial economy*. I am convinced, the original ambition of MOSES micro macro modelling to relegate *macroeconomics and static economic analysis to second best status* will therefore eventually be achieved.

1. A general perspective on expectations, market pricing, and economy wide market self-coordination

Along the way I have constantly been asked how this modelling project relates to standard theoretical designs of literature, notably familiar Keynesian demand driven macro models and to Schumpeterian inspired evolutionary models, but most insistently to neoclassical general equilibrium models. I have therefore found it necessary to explain those relationships, partly for didactic reasons, but also to clarify that while there are important distinguishing characteristics of the MOSES model, it does not depart from the fundamental principles of classical economics expounded in particular and already by ***Smith (1776)***, only from the barren model derivates associated with Walras, Arrow & Debreu (WAD) type static equilibrium models of the post WWII period (***Arrow and Debreu, 1954***). This Anthology has therefore been composed of publications that help achieve that understanding, and one such *distinguishing feature* - we will see- *is the lack of markets with economy wide self- organizing capacities populated by heterogeneous price setting agents in the above reference models*, a deficiency that creates the illusion that the economy is a controllable (by policy) economic system without a life of its own.

1.1. Integrates at least six familiar models – overcoming the partiality dilemma

The *Stockholm School* (theoretical) point of distinguishing between ex ante plans and ex post outcomes, and how agents learn from feed backs of mistaken anticipations that affect their behavior and influence macro, are distinguishing features of the MOSES model economy (***Eliasson, 2015***), as is market competition driven by entrepreneurial entry, that sequentially both forces agents to perform, or exit, and inform them through price signaling how to allocate their resources. *In that general market perspective individual decisions (in firms) can appropriately be likened with the design of economic experiments to be tested in markets* (***Eliasson, 1987b***; ***Eliasson, 1991a***). The MOSES model thus integrates *bounded rationality* characteristics of agents (***Simon, 1955***) with the push of *entrepreneurial entry* (***Schumpeter, 1911***) that creates a collective competitive force that compells incumbent agents to innovate preemptively, not to be competed out of the market (***Eliasson, 1995***; ***Eliasson, 1996***). All this dynamic occurs within a complete micro to macro and stock flow consistent Keynesian demand accounting scheme, and a Leontief input output production structure.[1] By taking the macro analysis down to the micro market level a theoretical link to ; ***Marshall (1890)*** and ***Marshall (1919)***'s concept of *industrial districts* populated by micro agents is furthermore established. With the entire model economy being *self-coordinated by the invisible hand of markets*, the MOSES model takes on not only distinctly Adam Smithian qualities, but the dynamics of market selection also creates the positive network productivity externalities that Marshall verbally formulated,[2] but that later became the cornerstone of so-called New Growth theory (***Romer, 1986***). In the MOSES model, however, network externalities are explicitly created by market induced reallocations of resources

1. In static general equilibrium prices map one to one onto quantities and vice versa. This property (mathematical duality) is the most simple illustration of the role of market prices as information signals about optimal production structures (***Jorgenson and Lau, 1974***). Dale Jorgenson has used that property to reorganize the US national accounts onto a more consistent taxonomy. The MOSES model differs from the general equilibrium model , that lacks markets, in that the duality has been broken up and explicit markets inserted between the prices and the quantities to self coordinate the economy, incurring a transactions cost in the process, and reducing the precision of market prices in signalling the "optimal" production structures for agents to aim for. See next section on what that means for the market governance of the economy. Developing that more general duality property using computer simulation mathematics would be an interesting study.
2. Marshall had the "empirical" ambition to make static equilibrium compatible with the increasing returns he could observe to occur in particular organizations of production and clusterings of labor that he called *industrial districts*. He demonstrated verbally how, what are today called positive *network externalities* were created, and that a temporary static equilibrium may be compatible in the short run with long run increasing returns. ***Romer (1986)*** demonstrated the same thing mathematically on a macro model populated by representative firms of atomic size (Romer does not quote Marshall). The concept of networking externalities belongs to equilibrium models that lack markets. Paradoxically, however, innovating MOSES firms that compete in explicit markets, and thus self-coordinate the model economy, achieve the same synergistic effects, incurring (contrary to both Marshall and Romer) transactions costs, and never come even close to an ex post static equilibrium. It does not exist as an operating domain in a MOSES (***Eliasson, 1991b***).

Table 1. The four mechanisms of schumpeterian creative destruction and economic growth.

1.Entrepreneurial competition (entry) in markets enforces
2.Reorganization of incumbent agents and/or
Rationalization, or
Death (exit)

Source: Eliasson (1995); Eliasson (1996):45.

among heterogeneous agents, that change the organization of markets (see Section 4.4.4). In fact, one novelty of the MOSES design is that selection of technological innovations driven by entrepreneurial competition, most prominently through the entry and exit of business agents through a Schumpeterian type of creative destruction (see ***Table 1***), and competing heterogeneous firms with autonomous price setting capacities together *constantly change production structures and make the population of firms endogenous.*[3] Therefore, Gerard Ballot and Erol Taymaz could demonstrate how new growth theory type"network externalities" may be created in MOSES markets by firms raiding each other for workers' skills (see Section 4.4.4).

Since the MOSES model by prior design is selection based, initial state dependent and therefore highly nonlinear it is prevented from *ever converging ex post onto a determinable exogenous equilibrium ("steady state") path, or for that* matter onto an analytically determinate stochastic equilibrium path.[4] The MOSES model thus distinguishes itself positively from neoclassical orthodoxy that lacks markets, including, surprisingly, also from agent based models where explicit markets naturally belong, as noted by ***Ballot et al. (2015)***. With this *empirically relevant specification,* however, comes problems of theoretical intractability and parameter estimation.

Experimenting with the economy wide market dynamics of the MOSES model, for instance, has gradually told me to be skeptical about the (empirical) relevance of the ergodic or (exogenous) equilibrium doctrine underlying received economic modelling, and argued by ***Samuelson (1968)*** to characterize a good economic model. It has rather convinced me of the necessity to embrace micro simulation mathematics to break out of the confines of economic orthodoxy to understand how markets work in self-coordinating an expanding economy, and what kind of transactions costs are incurred. By embracing the microsimulation method I can thus see a future of enormous untapped opportunities to advance general economic theorizing, and without breaking with the spirit of classical economics, but only escape the inhibiting toolbox brought into economics with modern neo -Walrasian mathematics.

Just in passing, the "disequilibrium" character and initial state dependency of *the MOSES model* economy means that it *must be empirically characterized before it can be subjected to general theoretical analysis*. I see that as a relevant and therefore positive characteristic of an economic model. In the MOSES world there is no such thing as pure general economic theory.

1.2. Market governance of economy wide self-coordination requires reasonable price predictability

In the MOSES evolutionary model approximation of what I call an Experimentally Organized Economy (EOE) price expectations govern economy wide behavior. *Market price expectations are integrated within the individual business plans of profit seeking production agents (firms) that grow by bringing in global best practice technologies through their endogenous investmets.* When attempting to realize these plans, agents must compete for resources in labor and financial markets and for income in product markets. *Competition forces all business agents to innovate preemptively to stay in business and to engage in individual ex ante long term expected wealth maximizing dynamic games, that must be constantly revised*. The outcome is a complex, constantly ongoing flux of winners and losers, economy wide success being associated with a dominance of the former, the latter being regarded as a normal transactions cost for economic development (***Eliasson and Eliasson, 2005***). Together it all amounts to a gigantic ex ante long run economy wide market self- coordination game propelled forward in time by production agents climbing ex ante profit hills, or if you like, as the entrepreneurial competition driven Schumpeterian Creative Destruction process stylized in ***Table 1*** and embodied

3. By contrast, production structures **in** the general equilibrium model by assumption remain unaffected by price change. It becomes static.

4. The impossibility for those reasons for rational expectations (RE) to ever reach an external stochastic equilibrium is theoretically clarified in ***Lindh (1993)***.

as the driving force in the MOSES model (***Eliasson, 1995***; ***Eliasson, 1996***). Economic growth occurs if winners dominate over losers in this market game. Since the ex ante profit hills, as perceived by firms, change from period to period, because of all the competitive profit hill climbing going on, these peaks will never be attained. Through innovation nudges and competition markets both govern the allocation of resources, force production agents to innovate, and self-coordinate an economy wide evolution, which rarely comes even close to what may be maximum possible at each point in time. Forcing the model economy closer to such a state by speeding up market competition (through policy) will eventually create increasingly unpredictable markets, raise business planning mistakes, and cause unstable economic systems behavior and perhaps even collapse (***Eliasson, 1991a***). Stable long run macro growth still, however, requires a significant turnover of firms, a steady churning of micro-economic structures and reallocations of resources over markets. As the publications of this anthology demonstrate, a MOSES type model economy exhibits such dynamic complexity that it is a vain hope for a central coordinator, like the Walrasian auctioneer, to be sufficiently informed to do a better job than the markets (***Eliasson, 1991a***; ***Eliasson and Taymaz, 1992***).

The MOSES model thus departs from both modern Neo Walrasian welfare theorizing and macro demand economics, and for that matter also from neo Schumpeterian economics, all being modelling without markets, and rather sides with ***Smith (1776)*** original treatise of the role of the invisible hand of markets in both self-coordinating the economy, and creating economic wealth and welfare. Dynamic markets must therefore be allowed back into economic systems understanding. The moral is that *economics without markets is a bad idea* (***Eliasson, 2023a***). This anthology should clarify technically what that perhaps surprising statement means.

1.2.1 Market failure or policy failure?

Market self -coordination, or equilibrating processes may malfunction, or even break down if (1) agents' expectations are grossly wrong, which may happen under disorderly market conditions caused by excessive competition, and/or too fast structural change (***Eliasson, 1991a***; ***Eliasson and Eliasson, 2005***), if (2) markets become too statically efficient ("too fast") in reducing redundancies and structural diversity (***Eliasson, 1984***; ***Eliasson, 1991a***), if (3) firm based innovations fail to compensate for the diversity reduction caused by competition and exit (***Carlsson et al., 1997***; ***Ballot and Taymaz, 1998***), and if (4) external policy interferences, for instance in the form of tax wedges in the price system, bias market incentives too far from the individual preferences of producers or income earners (***Eliasson, 1977***; ***Eliasson, 1980a***; ***Eliasson, 1980b***; ***Eliasson and Taymaz, 1992***). The distinction between market failure and policy failure to support market institutions therefore becomes hopelessly blurred.

Competition raises productivity and rates of growth, but if pushed too hard, for instance by policy, "destruction" will dominate over "creation" such that reduced diversity of production structures moves the economy into a collapse prone state. That situation will however be endogenously countered by innovation and entrepreneurial entry that raise structural diversity, and restore the growth promoting effects of competition, hold off destabilization and allow a faster growth rate. (This may sound like a theoretical abstraction of little empirical consequence. On the contrary, it is a highly empirically relevant theoretical concern as I will demonstrate below in section 2.3. A general experience from MOSES analysis also is that a market self-coordinated and advanced diversified industrial economy is a surprisingly robust economic composition. Note however in Sections 2.2 and 4.1 what may happen when a large, inflexible non-market economy is placed in the midst of the market self-coordination machinery, and in Section 5.4 that the Swedish economy was close to such a precarious state of diversity loss in the 1980s because of a decades long decline in entrepreneurial activity, most probably caused by the Swedish tax system and political attempts to socialize private industry).

1.2.2 Fast growth causes welfare trouble

Economic welfare is the ultimate concern of political economics. Markets are everywhere present in the life of individuals, and often, and for good reasons, represent tough economic environments for people. Welfare economics to be meaningful must therefore be based on an understanding of how markets work in self-coordinating an economy and in governing the allocation of resources.

I conclude from simulation experiments that *diversity of production structures* is a necessary condition for markets to function (***Eliasson, 1984***; ***Eliasson, 1991b***; ***Eliasson, 1991a***). Production structures, however, constantly change, and diversity is maintained endogenously by competition driven innovation and entrepreneurship that prevent the economy from ever converging into an analytically determinable stationary state. It therefore becomes natural *to relate welfare to the ability and willingness of individuals to cope with the constant and unpredictable structural churning that is inevitably associated with economic progress*.

Since constant micro structural change is complementary to, and a condition for achieving fast and steady macro-economic growth, the consequent local micro market instability and environmental unpredictability may overwhelm businesses and individuals, occasionally to become a welfare concern even in a successfully expanding economy, and force politicians to interfere in markets to hold back structural change and thus also growth. *In that perspective both economic growth and welfare become dependent on the social abilities to cope of the local population* (See ***Eliasson, 2001***; ***Eliasson, 2009a*** on the role of knowledge and *social capital* in economic progress). Obviously, to understand this dynamic complexity, mathematically clean equilibrium models will have to yield ground to more sophisticated micro simulation models, and my hope is that this anthology will clarify this.

1.3. A new equilibrium concept is needed

My argument for the necessity of non-equilibrium modelling is not the same as rejecting the idea that markets are capable of successful *economy wide self- equilibration*. I only note, what I have repeated for half a century, that a different and more complex equilibrium concept is needed than the one we read about in economic text books (***Eliasson, 1976a***). Economy wide market self- *equilibration* or self-organization in the MOSES model only requires that economic evolution stays within a range bounded from above and does not collapse. It becomes socially and politically desirable that this bounded range is narrow and expanding. What the above summary of simulation experiments demonstrate is that long term evolution of the macro economy will all the time take place well below what is at each point in time physically feasible, and that a bounded range equal to zero (a "steady stationary state") doesn't exist as an operating domain of a realistically modelled economy.

As pointed out by ***Day (1986)***, initial state dependent nonlinear models will now and then enter phases of deterministic chaos. Such local economic environments, that the MOSES model occasionally generates, are at odds with social welfare ambitions of Western democratic governments. in fact observed that such economic models may have a determinate exogenous equilibrium, or an attractor, outside the operational domain of the economy, that it never comes even close to, and that the model economy does not have to converge towards this equilibrium.[5] In MOSES terminology the ex ante optima mentioned above that each firm aims for, and revises from period to period will together constitute such a moving external attractor or "ex ante equilibrium" that constantly evades being reached ex post. It is therefore a mistake to aim policy at reaching it. These cosmological analogies may be a bit too abstract for empirically minded micro simulators, even though they might set creative imagination in motion. The same abstractions, however, relate to down to earth practical reality if the real world is nonlinear, selection based and initial state (history) dependent, which is more than likely. In such a world radically disturbed market environments occur now and then and make neoclassical welfare criteria based on achieving equilibrium states nonsensical. In the real nonlinear world they instead demand of policy makers that they not only understand what kind of disturbance the economy is heading for (a forecast), but also that they control both the short term and the long term outcomes of their interventions, which experience from MOSES modelling suggest that they will be uncapable of. The welfare interventions that such "experience" suggests, therefore, is rather to help individuals

5. Technically Day's macro models have been designed such that they unpredictably shift from one equilibrium model to another. Since the shift to a new equilibrium order cannot be predicted on data on the previous equilibrium order no one can prepare for what will come up. On this, MOSES may rather be thought of as a more general model which is constantly knocked out of order by the constantly ongoing structural change that reduces the predictive reliability of prices that in turn causes a new flow of investment and planning mistakes that again disturbs the predictive content of prices, and so on. Fortunately, under the normal circumstances of the calibrated MOSES model, the constantly disturbed economic environment seems liveable, and suggest that welfare policies should be focused on helping individuals to build the social capital needed to make market life comfortable (***Eliasson, 2009a***; ***Eliasson, 2009b***).

build social capital to cope with market disorder on their own (see ***Eliasson, 2009a*** and ***Eliasson, 2001*** on social capital).

Another interesting example of MOSES applications needing abstract thinking is the use of modern financial tools, for instance the CAPM method developed by ***Sharpe (1964)*** to predict market volatility. The CAPM method was derived from a static Walras, Arrow & Debreu (WAD) type of general equilibrium model that has nothing to tell on a world out of equilibrium. Since the MOSES model is constantly "out of WAD equilibrium", it became interesting to ask how reliable the Capital Market Pricing Model (CAPM) and its β coefficient were as a predictor of market risks when tested in the MOSES financial market environment and therefore by implication, in real world situations. This became possible when the new financial module of ***Eliasson and Taymaz, 2001*** had been installed (see further Section 4.6 and ***Broström, 2003***).

I have been constantly asked, from seminar to seminar, about the equilibrium properties of the MOSES model, and to say something about the seemingly subtle and unfamiliar policy problems associated with the unpredictable dimensions of MOSES economics. Static market clearing equilibrium where no agent has an incentive to move elsewhere doesn't exist as an operating domain in MOSES. Mathematically, pushing it there will create an infinite regress and economic systems collapse. It is technically possible to speed up market processes such that financial markets come close to clearing in the sense that all firms that survive this competition earn the same rate of return, which is at the same time equal to the interest rate, a classical neoclassical equilibrium condition. We have done that and found that when all firms become almost equal ("representative"), diversity of structures is gone, markets have just about stopped functioning, and the MOSES model economy has begun to swing wildly before it collapses. So, these abstractions are not entirely uninteresting. Remember, that when the neoclassical model is on a steady state the rate of growth equals the interest rate. But by then the MOSES model economy has already collapsed (***Eliasson, 1984***; ***Eliasson, 1991b***; ***Eliasson, 1991a***; ***Eliasson, 1991c***; ***Eliasson, 2005***; ***Eliasson and Eliasson, 2005***).

Welfare policy should thus focus on how markets function, not on achieving abstract market outcomes that cannot even be demonstrated to exist in a dynamic agent-based model with market self-coordination incurring unpredictable market transactions costs. It should come as no surprise that the *integration of partial models* by explicit market processes that make up the MOSES model economy has led to very different macro-outcomes than what each of the ingredient partial models would tell, as suggested already in ***Eliasson, 1976a***). Macro models, for instance, to exist as economically meaningful artifacts, require such extreme restrictions of market functions, that micro to macro theorizing will take you down a dead alley if the ambition is to establish a market foundation for existing macro theory, or make it compatible with existing equilibrium modelling, a point made already by ***Weintraub (1979)***, and reluctantly admitted by ***Fisher (1972)*** and ***Fisher (1983)***.

To understand economy wide market self-coordination without the help of the Walrasian auctioneer or a central planner was an ambition of the MOSES project from the start. Centrally planned and free market scenarios can be enacted and compared within the MOSES model (see for instance ***Antonov and Trofimov, 1993***).

An economy is populated by millions of heterogeneous agents with their own incompatible agendas that they express by having their plans tested in markets. *Fundamental economics therefore is about modeling how markets sort out compromises from those generally incompatible plans, and what transactions cost are involved*, not least in the form of economic mistakes being committed. It also places limits on central policy ambitions to govern the economy against the preferences of market agents, and to understand why pushing the wrong polices raise those transactions costs (***Eliasson and Taymaz, 1992***). To model the economy as a controllable economic system is therefore fundamentally wrong. ***Ballot et al. (2015)*** noted the absence of markets capable of economy wide self-coordination even in agent-based models and that attempts to model macroeconomic evolution without considering how agents interact in markets are a mistake.

While economists at Western universities seem to have had difficulties understanding that modelling economies as controllable systems without disturbing markets is fundamentally wrong, Soviet economists had first-hand experience of what it meant trying seriously. When the CEMI research institute in Moscow asked permission in the 1980s to use a stylized version of MOSES loaded with Soviet data to study the problems associated with transferring the centrally planned Soviet economy into a market economy (see below Section 5) they had understood that the MOSES model economy was market self-coordinated and featured a centrally planned economy as a special case. This illustrates how fundamental questions of economic theory and practical economics are closely integrated and can be studied using micro simulation methods. *It also highlights the importance of empirically relevant model design such that the categories of the internal artificial reality of the model economy become empirically familiar and can be related to interesting aggregate targets. A richly specified and empirically grounded internal artificial reality gives MOSES the capacity to tell about possible, not yet observed or thought of, empirical properties of a complex industrial economy, and to formulate new hypotheses to test on empirical data* (***Eliasson, 2018***). Regard the organization of this summary article as an attempt to clarify that philosophy.

2. Financial markets and competence blocs as allocators of resources

Financial markets trade in information and are therefore central to the efficiency of the allocation of real resources, the self-coordination of the economy and hence also for achieving long-term stable economic growth. The introduction of sophisticated financial market arbitrage in MOSES, substituting a capital market regime with trading in financial derivatives for the previous industrial banking system (***Rybczynski, 1993***) came with ***Eliasson and Taymaz, 2001***, and later elements of competence blocs with ***Ballot et al. (2006)***. This represented not only the first major upgrading of the MOSES model, but also illustrated the flexibility in both generalizing and calibrating the model that came with its modular design. Since price expectations are integrated within the business plans of firms this integration meant major change in the dynamic core of the model. Financial market transactions no longer took place independently of product and labor market transactions.

When firms subject their business plans to be tested against the incompatible plans of other firms, the markets sort out compromises and firms learn by feeding back their experience from such constantly ongoing market confrontations, revise their plans and try again (a Stockholm School feature). In the process business mistakes are made, prices and quantities are determined within and between periods (***Eliasson, 1976b***). The original modular design of MOSES was therefore instrumental in allowing the deep redesign of its core market mechanisms that the new capital market based financial system required. For instance, introducing financial derivatives that speed up market arbitrage , makes the MOSES economy more statically efficient, but may also disturb market arbitrage, reduce price predictability , and increase the rate of production and investment mistakes. Even though static efficiency is increased, long term macroeconomic growth may suffer, as simulation experiments show. Allowing insiders to inform markets by their trades, on the other hand, does increase long term growth (***Eliasson and Taymaz, 2001***. Up to a limit the innovation input of increased turnover of firms therefore raises long term sustainable growth. Business mistakes, however, eventually, as an increasing rate of structural change lowers market price predictability, begin to cumulate in numbers and sizes and to dominate the positive innovation push effects, and thus bend down the long term growth curve (***Eliasson et al., 2005***).

2.1. Type I and type II economic mistakes - Competence bloc theory

Competence bloc theory as formulated in ***Eliasson and Eliasson (1996)*** and ***Eliasson (2009a)*** introduced two types of economic mistakes in the allocation of investments; *Type I mistakes* occur when firms are late in identifying that an investment mistake has been committed, and in correcting it. *Type II mistakes* are incurred when firms fail to commercialize promising technical innovations. Type II mistakes can only be defined in MOSES type economy wide agent-based models in which markets, governed by human capital ("competence"), self-coordinate activities and allocate resources. During such much less than fully informed market selection winners may get lost for such long times that the loss becomes in practice permanent for the local economy. The more complete and diversified local competence blocs the lower the risk that winners be lost. The ultimate economy wide outcomes therefore depend on how market agents that perform that allocation are spontaneously organized to *learn from experience to identify promising technologies ("winners")* and support their commercialization. *Competence bloc theory* explains that. Hence, business mistakes committed by market agents will embody information that can be learned to improve next period anticipations and plans. All that is represented in the MOSES model. Under such circumstances economic mistakes and their consequences should, of course, not be represented by stochastic processes, and the economy

Table 2. Actors in the competence bloc.

1.Competent customers
Technology Suppliers
2.Innovators who integrate technologies new ways
Commercialization and scale up of new technology (markets for innovation)
3.Entrepreneurs who identify profitable innovations
4. Industrially competent venture capitalists who recognize and finance entrepreneurs4.
5.Exit markets that facilitate ownership change
6. Industrialists who take successful innovations to industrial scale production
Scale down
7. Rational and efficient liquidation (Exit)

Source: Eliasson (1995)Eliasson (1996a).

should not be modelled as a stationary process, a conclusion that brings up not only the absurdity of the rational expectations (RE) proposition, but also the relevance of the old distinction of ***Knight (1921)*** between risk and uncertainty (***Eliasson, 2015***). Competence bloc theory allows for winners to be permanently lost to the local economy, a possibility neoclassical economists tend to object to by arguing that in the end somebody else will come up with the same winning technology; an "ergodic" assumption of sorts.Perhaps, but it may be somewhere else and many years from now. The short period long term dynamics of the MOSES model in fact also embodies an answer to this. While winners may get lost (Type II mistakes), endogenous innovation,entry and commercialization in MOSES migh quite possibly generate long term winners that compensate for previously lost winners at some higherm level of aggregation. The point made in MOSES modelling is that the net flows of captured and lost winners over the longer term may be both positive and negative, and the difference will cumulate over time into sizable differences in economic wealth created, for instance, for a regional or national economy.

2.1.1 Actors in the competence bloc

Competence bloc theory lists the minimum of market actors that participate in the creation, commercialization and scale up of new technologies (see ***Table 2***). Since those activities can take place both within a hierarchy, a firm, and in markets, competence bloc theory becomes the natural framework to explain the formation of business hierarchies or firms. Competence bloc theory is briefly explained in ***Ballot et al. (2006)***. For a full explanation see ***Eliasson (2003)***; ***Eliasson (2009a)***; ***Eliasson (2009b)***; ; ***Eliasson (2023b)***; ***Eliasson and Eliasson (1996)***; ***Eliasson and Eliasson (2009)***. In a vertical recursive commercialization and scale up sequence *entrepreneurs* identify ("discover") and integrate profitable new *technological innovations* and team up with *industrially competent venture capitalists* to bring the project closer to market. If cleared as a potential winner, the venture capitalists want to cash in and pass the project on to the *private equity markets* with more resources for volume scale up. The project may eventually reach *industrial scale* and be prepared for a stock market introduction (an IPO), or be acquired by an industrial buyer that needs to complement its technology portfolio. The competence bloc needs to be *vertically complete* for winners not to be lost along the way (Type II mistakes). The diversity of today's industrial technologies also requires each vertical layer of agents to be *horizontally diversified* for a matching of innovations and entrepreneurial competences with resource providers to be sorted out and secure a safe vertical passage for winners.

The birth, the life and the death of production agents are thus governed by the financial intermediators of competence blocs. The competence bloc has therefore not been fully categorized until the final stage shut down and *exit* has been recognized, and an ongoing Type I mistake eliminated. To be noted is that the death (exit) of business agents is deterministically modelled and occurs when some minimum profitability targets have not been satisfied for long, and at the latest when the firm has depleted its equity (***Eliasson, 1976b***).

Complete and diversified competence blocs are rare even in advanced industrial economies, but they are empirically well defined and both their existence and the industrial competence of the different resource providers can be both directly observed and evaluated (***Eliasson, 2003***; ***Eliasson, 2023a***; ***Eliasson, 2023b***). Complete and diversified competence blocs therefore represent a competitive advantage of a national economy of the kind the United States has for long benefited from compared to Europe (***Eliasson, 2003***; ***Eliasson, 2022***). Since the base for this superior competitiveness is the competence of local markets to identify , capture, support and successfully commercialize and scale up winning technologies, a local attractor of global financial resources has been created and sometimes on the scale needed to fund the commercialization and rapid scale up of for instance technology giants like Apple, Amazon, Alphabeth, Facebook, SpaceX and Tesla. The critical supporting factors behind those business successes are not only new technologies or entrepreneurial talent, but also the industrial competence of local competence blocs to move massive financial resources perseveringly in the right direction. Such complete, diversified and resourceful competence blocs have spontaneously emerged in US financial markets over a long time. The conclusion is close that the almost complete absence of such new technology giants in Europe is due to the dilution of industrial competence in the European financial communities the resources of which having in the post WWII period become governed by bureaucrats directed by political ambitions that has reduced the industrial competence of European venture capital finance. This is not the right organizatiopnal solution to create European technology winners to beat the US ones. Policy directed policy failure is a more appropriate characterization (***Eliasson, 2022***).

When vertically and horizontally "complete" a competence bloc has reached *critical size*, such that potential winners can confidently carry on their search for resources to be eventually understood , provided with resources and sucessful. Since nobody can know for sure until the very end who will be a winner, succesfully economy wide outcomes in an Experimentally Organizsed Economy require a large number of business excperiments, and the economy will have to cope with a correspondingly large number of failed experiments. And it will never be known for sure whether the best of all possible selections (allocations) has been attained, since the data generated by the economy won't contain all the informatin needed to determine the location of such an optimum state. Above all, central actors, like policy minded government bureaucrats are unlikely to possess the commercial abilities and instincts embodied in complete competence blocs to outperform all privately greedy and commercially experienced market agents together. Adam Smith understood that. Such is also the nature of an Experimentally Organized Economy.

2.1.2 Venture capitalists in MOSES

Venture capitalists are a critical category in the competence bloc and the most studied, even though the importance of their industrial competence to achieve successful commercialization and scale up to macro of technological winners took long to be recognized (***Eliasson, 2003***; ***Eliasson, 2005***). Venture capitalists were introduced in MOSES in ***Ballot et al. (2006)***, who demonstrated that financial actors that had acquired industrial competence through learning from experience from previous investing, notably from their mistakes, improved the investment outcomes of financial allocations and long term economic growth, notably by reducing the incidence of type II mistakes. In a long-term perspective Type II economic mistakes are the most important to avoid ***Eliasson and Taymaz (2021)*** demonstrated in MOSES experiments. They concluded that complete competence blocs appear to be a major growth enhancing market "institutions" in an advanced industrial economy, and that understanding opportunity costs therefore becomes a critical guiding principle for policy makers in MOSES economies. There is thus no reason to assume that social costs in the form of foregone long term economic value creation are small. On the contrary we may be considering the consequences of fundamental changes in the organization of advanced economies and how to cope sucessfully with them. The massive reorganizations of the worlds's largest economy in the past decades mentioned above that have made the US economy grow faster than almost all industrial economies point to the importance of the industrial competence of financial markets (read conpetence blocs). There is also the obvious corollary that European policy ambitions to redirect venture capital provisions under the governance of bureacrats has reduced that same industrial competence in the European financial community. This has not only reulted in a self inclicted European policy mistake of perhaps massive dimensions. It may also have prevented the European economies from developing the technology giants politicians are craving for (***Eliasson, 2003***; ***Eliasson, 2022***). To make the situation worse , the experience based industrial competences needed in the finacial community, to judge by MOSES simulation analyses, may take very long to build (***Ballot et al., 2006***). To sum up, the policy morale reads: (1) encourage bold investments in private markets governed by free competitive entry, (2) promote market competition to identify and correct business mistakes fast, and (3) make sure that complete competence blocs have been both allowed, and politically encouraged to develop spontaneously to minimize Type II economic mistakes. Finally (4), regard Type 1 mistakes as a standard costs for economic development that are necessary to minimize the risk of committing the far more socially costly Type II mistakes (***Eliasson and Eliasson, 2005***). Competence bloc theory is a time sequenced schedule of human capital (competence) based decisions that may be taken independently in markets, or are internalized within hierarchies. It is therefore the perfect blueprint for modelling the endogenous formation of firm hierarchies in markets (*Eliasson, 2023b* and Sect. 4.5 below).

2.2. The public sector and taxes below

No serious study on tax and transfer heavy economies like the Swedish one can abstract from the public sector and its financing. The public sector in MOSES figures as a huge non- market economy superimposed on, and integrated within its core market economy through the large tax wedges associated with its financing, that bias price signaling in markets. The mere presence of this rigid lump in the midst of the market machinery thus raises the risk of distorted prices and concerns about market incentives and consequently of business mistakes. Even in this crude form as a producer of public services distributed free of charge, and a reallocator of incomes, the MOSES public sector is thus of great principal interest.[6]. The modular design of MOSES makes the integration in ***Eliasson (1980b)***, republished in this anthology, of taxes and transfers, and the placing of an inflexible non market public sector in the midst of MOSES markets, technically easy and the consequent accommodation problems empirically obvious (see Section 4.1).

Long before the concept of Type I and II mistakes had been formulated, ***Eliasson and Lindberg (1981)*** had demonstrated in MOSES experiments that even major investment mistakes (in their case caused by large tax wedges in the price system) had small economy wide effects if they were identified early as mistakes, and promptly shut down. The Swedish industrial support program of the 1970s and 1980s, when subjected to an economy wide cost benefit study on MOSES (see Section 4), became an extreme version of late understanding and failure to correct. The large economy wide costs were in both cases incurred by keeping workers locked up in mistaken, low productivity production, depriving the economy of their higher productivity inputs on other jobs.

2.3. Tying up the bag - Theoretical validation

Before moving on to the empirical validation of the MOSES model the theoretical bag must be tied up. MOSES has had an uneasy relationship with conventional Keynesian macro and neoclassical economics, and for both good and bad reasons. The latter both hinge on the equilibrium concepts of neoclassical orthodoxy, and the impossibility of making macroeconomics compatible with an economy self- coordinated by market agents with price setting autonomy. What makes MOSES economics depart from economic orthodoxy is the lack of markets in both. Making aggregation endogenous over dynamic markets, and breaking up static equilibrium to introduce Stockholm School ex ante -ex post economics at agent levels, not only provides an answer to the perennial question asked for instance by ***Arrow (1959)*** and ***Lindbeck (1966)***, who sets the prices when Walras auctioneer isn't there to do it? Breaking up static equilibrium also puts life into economic theory.

2.3.1 Who said interesting things about this before? Breaking up static equilibrium

Clower (1965) is very clear. Neo – Walrasian " orthodox economics provides a general theory of equilibrium states"….."Clearly, however, orthodox analysis does not provide a theory of disequilibrium states", because it has nothing to say "on the magnitudes realized as distinct from planned transactions under disequilibrium conditions". Hence, neo-Walrasian orthodoxy has nothing to say on how an economy moves from one equilibrium state to another under disequilibrium conditions governed by market price signals. This is an implicit recognition of Stockholm School economics that Clower doesn't seem to have been aware of. Keynes understood that , Clower continues. However,

6. In its present form MOSES is prepared, thanks to its modular interfaces with the rest of the economy, to feature the public sector as a competing producer of possibly spillover intensive, privately demanded services such as health care, social insurance and education. Data collection for this extension has in fact already begun in the so called HUS project in which data on the demand and use of these services of households have been collected (see ***Eliasson and Klevmarken, 1981*** and ***Eliasson, 1982***.

and this is one theoretical novelty of MOSES economics, if (as in ***Eliasson, 1976a***) building the MOSES model bottom up on algorithms based on observations (in ***Eliasson, 1976a***) on how firms form price expectations, make up plans, react to, and learn from these plans that constantly fail to be realized as planned, when they are confronted with other agents' plans in markets, you will find that *no ex post neo - Walrasian equilibrium to head for exists*. Why this is so I have already explained (Sect 1.3 and ***Eliasson (1991a)***. ***Clower (1965)*** claims that Keynes understood all this, and had the wider theory needed to discuss ex ante and ex post economics "at the back of his mind, or most of the *General Theory* is theoretical nonsense".

It makes sense to distinguish "between plans and realizations" Clower continues (Op cit page 284), and in that perspective *Say's principle* becomes "essentially a rational planning postulate" (p.285). By reformulating Stockholm School principles in MOSES such that the differences between ex ante and ex post outcomes feed back as mistakes and experience to learn from (***Eliasson, 1976b***) MOSES provides a mathematically explicit and complete micro market selection based version of the wider model Clower argues that Keynes must have had at the back of his mind. This is the second novelty of the MOSES model.

The last couple of decades have offered several rescue operations of static general equilibrium economics to deal with its extreme assumptional foundations. The rational expectations (RE) and real business cycle theories are two examples. As it seems, but someone else will have to prove it mathematically, the MOSES model does not approximate a stationary state and therefore is not compatible with the RE proposition (***Eliasson, 2018***).[7] The reason for this incompatibility is its selection based initial state dependency and that it now and then exhibits phases of deterministic chaos, a phenomenon that ***Carleson (1991)*** relates to probability theory. ***Day (2004)*** initial state dependent nonlinear models with chaotic properties are the natural way to represent dynamic economics. Hence, quoting ***Day (2000)***, RE amounts to no more than "a statistical description of data". This makes it interesting to ask whether generated trajectories of MOSES, that now and then exhibit chaotic properties, can be approximated by a stationary process and thus RE based, for instance as a real business cycle model as proposed by ***Kydland and Prescott (1982)***

Finally, and importantly, the understanding, brought into economics by Richard Day, that in a wide class of non linear initial state dependent economic models, including the MOSES model, minor occurrences may cumulate into major economy wide phenomena ("deterministic chaos"), also defines limits to our understanding of economics. As I will come back to in the next section this also emphasizes the importance of high quality economic measurement. All relevant economic models are empirical in that data (measurement) enters at some place, and even small errors of measurement may take on economy wide proportions with time, and be interpreted as something economic to react to.

2.3.2 What equilibrium?

This takes us back to the problem of defining *a meaningful equilibrium concept for a market self-equilibrated or self-coordinated economy*, argued in section 1.3 to be a priority concern for economic theorizing. Since *the MOSES model does not have a unique and externally determinate equilibrium* of the neoclassical kind, and since wherever the MOSES model economy is heading, its trajectory will depend on the initial state and on the market transactions costs incurred along the way, *markets will never be able to direct the economy towards a unique such trajectory irrespective of initial conditions*. On the contrary, Monte Carlo validation experiments on MOSES demonstrate that trajectories fan out considerably over the long run depending on initial conditions and how the critical market transactions regulating parameters are set, the committing of Type II economic mistakes become a critical determinant of the diverse outcomes (***Eliasson, 2001***; ***Eliasson and Taymaz, 2000***).

We have often tried to push the MOSES model economy towards something that resembles a capital market equilibrium where all remaining firms' rates of return converge and close up with the rate of interest by speeding up markets and eliminating type I economic mistakes faster, only to find that as firms become increasingly equal ("representative"), and grow at similar rates in

7. ***Lang (1989)*** demonstrated that the narrow mathematical foundation of RE was in fact clarified already in Herman Wold's doctoral dissertation on the properties of stationary time series (***Wold, 1938***).

pace with the macro economy, as low performers are exiting, the heterogeneity or diversity of production structures, the very foundation of a market economy, is reduced and the entire model economy becomes wobbly to eventually collapse (***Eliasson, 1984***; ***Eliasson, 1991b***; ***Eliasson, 1991a***).[8] So, there is no support for the long run existence in the MOSES model economy of the underlying stationarity of the RE proposition or the real business cycle idea. And satisfactory long run systems properties are basic to both the theoretical and empirical validation of the MOSES model. The equilibrium concept we are looking for must therefore be something very different from what economic orthodoxy assumes to be fundamental. For me it boils down to identifying a parameterization of the model economy that keeps aggregate output constantly safely above zero, and long term growth reasonably stable nd not to far below the upper constraint defined by the "best practice technologies" brought in by firms' endogenous investments. To "maximize" the rate at which the bounded region within which the economy progresses, and to “minimize” the fluctuations of the economy within that same bounded region may be a desired policy objective. But there are clear limits to what can be achieve witout causing more social damage than the benefits of such countercyclical policies are worth. The bounded range of economic progress must not be made too narrow (by policy) , because faster economic growth is unavoidably associated with a constant churning of structures forcing factors of production to be reallocated over markets. This is practical down to earth simulation analysis that will be conditioned each time by (1) the initial state vector, (2) by the most realistic projection of “best practice technologies”, and (3) by projections of remaining exogenous variables (see Sections 3.2 and 3.4).[9] This dynamic raises a new and unfamiliar perspective on welfare economics and business cycle policy, a new perspective created when the Stockholm School economists and Joseph Schumpeter are allowed into the orderly garden of neo Walrasian economics.

2.3.3 Diversity of structures must be endogenously maintained for ever

Eliasson (1984); ***Eliasson (1991b)***; ***Eliasson (1991a)*** made it clear that the markets of the MOSES model economy would stop functioning, and the economy would come close to collapse if the heterogeneity of the firm population and the diversity of production structures were reduced beyond a critical limit. “Representative firms” are not compatible with the existence of markets. On this we found that ***Schumpeterian (1911)*** entrepreneurs, slightly remodeled fulfilled the dual roles in the market economy of (1) *self-coordinating* the economy by keeping markets dynamically competitive, and (2) forcing incumbent production agents to constantly *innovate preemptively* for fear of otherwise being competed out of business (***Eliasson, 1995***), and thus together keeping production structures upgraded and diversified through those same innovations.

2.3.4 Structural change reduces the information content of market prices

In static equilibrium, structures reflect prices, and vice versa (mathematical duality). Out of equilibrium structural change caused by price change, as in MOSES, reduces the predictive content of prices. Price expectations fail to come true and economic mistakes are committed. The final word that ties up our theoretical bag is ***Eliasson, Johansson and Taymaz (2005)***, republished in this anthology, who demonstrated that Schumpeterian entrepreneurial competition keeps the economy going with upgraded diversified and increasingly more technologically advanced production structures, but does that only up to a limit. Eventually structural change becomes too fast and begins to disrupt market order and reduces the predictive information content of prices, such that production and investment mistakes and exits escalate, transactions costs begins to accelerate, and to dominate over the positive growth contributions of innovations. Simulation experiments suggest that in a diversified, and thus structurally resilient, industrial economy those critical limits are far off. A worrying sign, however, was that the reduced structural diversity of Swedish manufacturing structures had become statistically very visible in the 1980s, a fact that was not taken seriously at the political level (see Section 5.4).

8. Remember here (see Section 1.2). that the market dynamics of the MOSES economy can be likened with a gigantic market governed ex ante economic wealth maximizing process that shifts direction as market circumstances change. Mathematically that optimization process will become increasingly shifty as the diversity of structures is reduced and the ex ante objective function increasingly flat.

9. Note in Sector 3.2 that ***Ballot and Taymaz (1998)*** endogenized innovation and that upper technology constraint, and what that might imply (see section 6) for the nature of an xperimentally Organized Economy.

With entrepreneurial entry both driving market competition and forcing agents to innovate preemptively out of fear of otherwise being competed out of the market (exit), we have come up with a complex market selection based non linear (non ergodic) initial state dependent model economy featuring sequential (recursive) market processes that self-coordinate the entire economy, the specification of which on empirical grounds is greatly superior to competing economy wide Keynesian macro models and static neoclassical versions, and for that matter ***Schumpeter (1942)*** inspired innovation systems models. ***Schumpeter (1911)*** entrepreneurship combined with Stockholm School ex ante -ex post expectational dynamics explain the difference. Were it not for the difficult estimation problems MOSES would therefore already have deposed these competing partial models into a second-best state).

3. Setting up MOSES as a Sweden like industrial economy – Empirical validation

The MOSES modelling project began in late 1974. As explained in ***Eliasson (1976b)*** IBM Sweden took the initiative and provided mathematical, programming and computer support for two years. Project work was located at the Federation of Swedish industries, the chief economist of which I was at the time, and at the University of Uppsala.

The declared ambition was to build a micro based model that would empirically represent the evolution of an advanced industrial economy in a global market environment, and notably one "being capable of" representing the market disorder prevailing among the industrial economies at the time the project was started in the wake of the 1974/75 oil price shock. To relate market disorder to macro a micro firm based approach was a must. *The focus was to be on explanation over the longer term, not forecasting*. I was sent around by IBM, notably to US universities and research institutions, to check if some similar projects were in the works. IBM was not interested in supporting a repeat of something already done, but keen on an innovative approach to economic modelling, especially if computer intensive. There was not much to see, except Barbara Bergmann's project at the University of Maryland and Guy Orcutt's group at Yale. Reference groups were established in IBMs economic research centers in Pisa (Italy), Peterlee (UK) and in Stockholm. At IBM's research center at San Jose I got several presentations of the use of mathematical simulation methods in other sciences. Particularly innovative, and something to learn from, especially by academic institutions, was that IBM assigned "managers" with research background, not to direct, but to simply be interested and ask questions about the progress of the project.

The ambition of the MOSES project should thus be understood against the backdrop of the global stagflation that had just begun, an inability of the economics profession to credibly explain what was going on, and business leaders' worries about government tendencies, nevertheless, to intervene ambitiously in markets. The latter reflected concerns in the business community, notably among members of the Federation of Swedish Industries, and an irritation about the lack of attention paid to the role of firms in macro development by economists and politicians alike. Consequently, *empirical relevance should guide the specification of the model, not compatibility with any economic doctrine*. The dynamic characteristics of a real market economy simply had to be represented in the model design. Since I was just about to conclude an interview study of planning practices among (mostly large) US and European manufacturing firms, to be published as ***Eliasson (1976a)***, I did not hesitate about how to proceed but was concerned to model those observed practices such that they appeared familiar to managers in real firms. Model specification, and in particular an amply typified *representation of the artificial reality of an advanced industrial economy* that was needed to minimize the partiality problem came first. The microsimulation method was attractive because it allowed specifications that substitute direct measurement of observed sequential short period decision processes for artificial analytic representations, such as distributed time lags. Database quality has thus been a supreme concern throughout the MOSES project, witness the Data Base documentation in ***Albrecht (1992)*** and the Appendix. Parameter estimation, even though important, has been a third order concern after specification and high-quality data collection (See further the short history of the MOSES project in ***Eliasson, 2018*** and a longer version in ***Eliasson, 2025***).

This section is about the empirical validation of the MOSES model. It begins with the empirical grounding of the model's specification, followed by database design and compilation, and parameter calibration. After that I report on the sensitivity analyses routinely conducted to make sure the model economy behaves well over the longer term. I illustrate with examples how these sensitivity analyses have identified specification problems that were then corrected.

3.1. Specification and Database Support

The early versions of the MOSES model consisted of the micro based dynamic market core documented in ***Eliasson (1976b)***, that integrated Schumpeterian entrepreneurship with Stockholm School expectational feedbacks within a Keynesian *demand* structure such that all incomes generated, after having been taxed down, were run through a Stone type expenditure system estimated by ***Klevmarken and Dahlman (1971)***. The latter had been inserted in MOSES after some nonlinear features had been added (investment demand and demand for intermediate goods were modelled at firm level). Very soon thereafter the production structure of the model was expanded to be based on a complete eleven sector input output model restructured onto the OECD End Use classification to be compatible with the market categorization firms used in the micro data we collected in a separate survey, the *Planning Survey* of the Federation of Swedish Industries. Four sectors or subindustries could now be populated with (data on) real individual firms (see Appendix). From above, the *model now* came out as a familiar eleven sector Leontief – Keynes *model* (see Figure 2.1 in ***Eliasson, 1980a*** Republished in this Anthology).[10] An estimated such sector model was at the time available from a separate project at the Industrial Institute for Economic and Social Research (IUI) that I had been involved in putting together and had access to. Several production sub industries (in MOSES currently five) in that sector structure could now be carved out and replaced by any number of heterogeneous and *boundedly rational* or "ignorant" firms in the sense of ***Simon (1955)***.[11] The individual firm data needed to put the model on an empirical footing was at the time not available, so a new *Planning Survey* project (***Virin, 1976***; ***Albrecht, 1978***), was started at the Federation. Questions were formulated based on information from ***Eliasson (1976a)*** on what kind of data firms themselves based their decisions on, and designed to serve the needs of the model.[12] To establish a micro to macro and stock flow consistent initial state database was therefore of great principal importance. Firms in the MOSES model base their decisions on data that (1) reflect the "disequilibrium" situation in the real economy, but (2) are also afflicted by statsistical errors, most important the errors that depend on inconsistencies between public Nataional Accounts (NA) and Planning Survey data, that were concentrated in the synthetic firms created from the differences between NA data and the aggregated Planning Survey data for each market to scale the model up to NA level. It was importanrt that these statistical errors be minimized, since in non linear initial state dependent models of the MOSES type they tend to cumulate (see Appendix (Section A.1.5), and ***Albrecht et al. (1992)*** on how that high quality data base was constructed for the 1982 initial state).

10. The Leontief – Keynesian sector model is an empirical derivate of the general equilibrium model, as are also later computable general equilibrium models, all being economic systems models without markets.

11. One statistical problem was that the sectors of the input output table were based on a production taxonomy, while the statistical systems of firms are based on the market taxonomy used in the annual Planning Survey conducted by the Federation of Swedish Industries. This survey contributed the firm data needed to specify the initial state for MOSES simulations, and with time provided panel data for testing simulated distributional characteristics. The incompatibility between the market demand taxonomy of the firm data (collected in the planning Survey and used in the MOSES model) and the production taxonomy of NA statistics thus became a problem. For how that problem has been solved, see ***Albrecht (1979)*** and ***Albrecht et al. (1989)***. This statistical dichotomy is however of principal economic interest since both real firms and MOSES firms base their decisions on the data collected in the Planning Survey, and thus react to both these statistical "errors" and the "reality" reflected in the data. For various reasons these errors may be initially much too large in that some of the" synthetic" firms crated from the residual between the NA data and the sum of all Planning Survey firms come out much too wrong. By running the model for a few years, the endogenous market machinery of the model eliminates the extreme "outliers" among the synthetic firms, and a new and micro to macro and stock flow consistent initial state has been established (For more on this "breaking in" procedure (see ***Taymaz, 1992b***).

12. But also to be used for the business cycle forecasting of the Federation that my department was responsible for.

3.2. The global upper technology constraint and innovation

Business agents invest, and with each new endogenous investment vintage new "global best practice technologies" from an exogenous *global pool of technologies* are brought into the production system of the firm (for details see **Eliasson, 1976b**). Supplies of individual firms are thus restricted from above by the labor and capital productivities of these best practice investment vintages that firms access through their endogenous investment decisions. With **Carlsson et al. (1997)**; **Ballot and Taymaz (1998)**; **Ballot and Taymaz (1999)**, firms investing boldly in R&D could locally improve upon those globally available best practice technologies (innovations), improvements that were in turn made locally available through an upgrading of the global pool of best practice technologies in **Ballot and Taymaz (2012)**.

The MOSES model was used early to clarify the relative importance of new technologies and markets in the commercializing and scale up of new technologies for a joint project between IUI and the Swedish Academy of Engineering Sciences (IVA). This so called "Grand Project" came in handily (for us) to obtain data on best practice technologies. In a survey to IVA's members (mostly technology directors at Swedish firms) historic data on best practice technologies were collected that could be used to calibrate the MOSES model (see **Carlsson et al., 1981** and IVA project in Section 4.2).

3.3. Stockholm School expectational feedbacks (learning) and Schumpeterian entrepreneurs keep the MOSES economy structurally diversified and resilient

Business agents in MOSES with different production structures and market experiences make up their plans and decisions based on *Stockholm School adaptive price anticipations with learning feedback. Expectations are always more or less mistaken* (*even "in expectation"*). *Ex ante - ex post differences therefore include economically valuable information that firms interpret (learning) and recycle as experience to improve next period (quarter) anticipations.*[13] This Stockholm School feature is a novel element of MOSES economics, that makes mistaken decisions the main market transactions cost incurred.[14] On top of this feedback dynamic, markets in the MOSES model are constantly disturbed by *Schumpeterian entrepreneurs* that enter unexpectedly, causing Schumpeterian Creative Destruction on existing production structures and forcing failing incumbent actors to exit, leaving in their wake an endogenous population of business firms (**Table 1**). Expectations and economic incentives make firms invest and grow, and exert, together with Schumpeterian entry, a collective competitive pressure on all incumbents. Such competitive challenges force them to *innovate preemptively* (**Eliasson, 1995Eliasson, 1996**) through engaging in higher risk R&D investments (**Carlsson et al., 1997**; **Ballot and Taymaz, 1998**), to forestall being competed out of the market (exit). This ex ante - ex post dynamics is necessary and sufficient to keep market competition driving economic evolution forever, but not sufficient for economy wide systems stability.

Entrepreneurial entry, however, performs the dual role of both forcing incumbents to produce more efficiently (competition) and to upgrade production structures (innovation), thus maintaining structural diversity in MOSES simulations. The latter diversity enhancing function is the final dynamic element required to keep economic systems evolution resilient and not easily destabilized **Eliasson, 1984**; **Eliasson, 1984**; **Eliasson, 1991b**; **Eliasson, 1991a**; **Eliasson, 1995**). A complicating factor is that structural change may become too fast, reducing the reliability of information signaling in markets, and hence possibly growth by raising the incidence of business mistakes excessively. Cumulating

13. See section 2.2.1 in **Eliasson (1976b)**, republished in this anthology. Expectations are hence not rational (RE). However, if relative foreign prices are set exogenously to follow a "steady state" development, firms will, with time, and based on their adaptive expectations, "learn" to be right in expectation. Hence, if foreign prices are predictable in that way a centrally planned economy may come out favorably in comparison with a free market regime by forcing agents' plans in line with central forecasts. Cf discussion below in Section 3.4 of what may happen when foreign prices are endogenized and made dependent over the longer run on erratic new technology innovation.

14. An observation first made by **Dahlman (1979)**, an earlier IUI researcher. Dahlman defined transactions costs as the consequence of market imperfections or departures from a static equilibrium that does not exist in MOSES. In MOSES market transactions costs are incurred as the consequence of mistaken anticipations and decisions, causing Type I and Type II mistakes (see Section 2.1).

transactions costs through escalating investment mistakes then eventually destabilize the economy and lower growth (***Eliasson et al., 2005***).

3.4. The global market interface

MOSES firms export a share of their products that depends on the relationship between the (exogenous) global price and the (endogenous) domestic price firms fetch (***Eliasson, 1976b***). In foreign markets MOSES firms are currently price takers.

Inputs in each market are similarly governed by relative price dependent macro import functions. Even though historic ex post simulations and parameter calibration are based on registered price data, general MOSES experiments must carefully define the relationships between foreign and domestic prices in each market such that they become compatible in the long run with global best practice productivity brought into firms through their endogenous investments. One could perhaps say that the global economy is assumed to be in approximate global steady state equilibrium. Exogenous foreign prices, including the global interest rate, therefore had to be *exogenously calibrated in experiments such that firms investing in those best practice technologies would earn a return (on the margin) approximately equal to the global interest rate* (***Eliasson, 1983***). The technically interested reader will observe that this exogenous specification is a "soft ergodic" assumption that has been sneaked into the model through the back door. I consider this a temporary deficiency that should be possible to remedy by calling in ***Ballot and Taymaz (2012)***, who have modeled a global economy of *MOSES clones* that are integrated by the diffusion of new technologies between the cloned economies. Firms in those cloned MOSES economies imitate superior firms in other cloned economies, a specification that can be more generally interpreted and modeled to include different kinds of interaction, including direct trade in technologies, foreign direct investments (FDI) and the movement of human capital by allowing firms to recruit across borders very much as already done within the MOSES model (see ***Eliasson, 1976b*** and sections 4.4.4 and 6.2 below). Since local innovations in individual firms will also upgrade the global technology pool, innovations in one economy will therefore globally diffuse through trade in technologies and be made available to firms in all (cloned) MOSES economies through their endogenous investments.

In studying the consequences for the MOSES model economy of the oil crises of the 1970s, oil price shocks were entered exogenously to disturb global market order. They thus hit the Swedish economy as unexpected price shocks in export and import markets that MOSES firms had to cope with, destabilizing the Swedish economy , and very much so, as the inflationary consequences diffused for years through the markets of the model economy (***Eliasson, 1978a***; ***Eliasson, 1978b***).

The endogenization of local productivity development by ***Ballot and Taymaz (1998)*** opens interesting possibilities to escape the long run global market equilibrium or soft ergodicity assumption of the current MOSES design, and thus to endogenize global price determination. With productivities endogenized as in each local economy competition in local (cloned) markets and globally through international trade as before, global prices in each submarket will be endogenously determined. It will have to be a principally simple but dynamic design, that would still be preferable to the current static global "steady state assumptions". This is an interesting proposition for the future (see Section 6.2).

3.4.1 Accounting stock flow consistency (SFC)

Fundamental to MOSES economics, or the Experimentally Organized Economy (EOE), is that agents' price expectations and plans are never mutually consistent ex ante, but that markets are constantly at work trying to eliminate inconsistencies, however never arriving at a consistent equilibrium *because the circumstances at each moment of this market arbitrage change the circumstances for the following moment*. Trade is constantly taking place, and as agents register the transacted prices and quantities, they revise their expectations and plans and adjust inventories accordingly. Ex post registered accounts will therefore be framed ex post (however not ex ante) within a *micro to macro, stock flow consistent (SFC) National Accounting (NA) framework* ***Eliasson, 1976b***. The MOSES model is SFC because it keeps track of all items in the balance sheets of all agents (firms, households, the bank, the government and macro sectors like construction) throughout a simulation. Nothing disappears from, or appears in the model. ***Albrecht (1992)*** documents the exacting work associated with compiling the micro macro, stock flow consietent initial state for MOSES for the year 1982. Indirectly this consistency

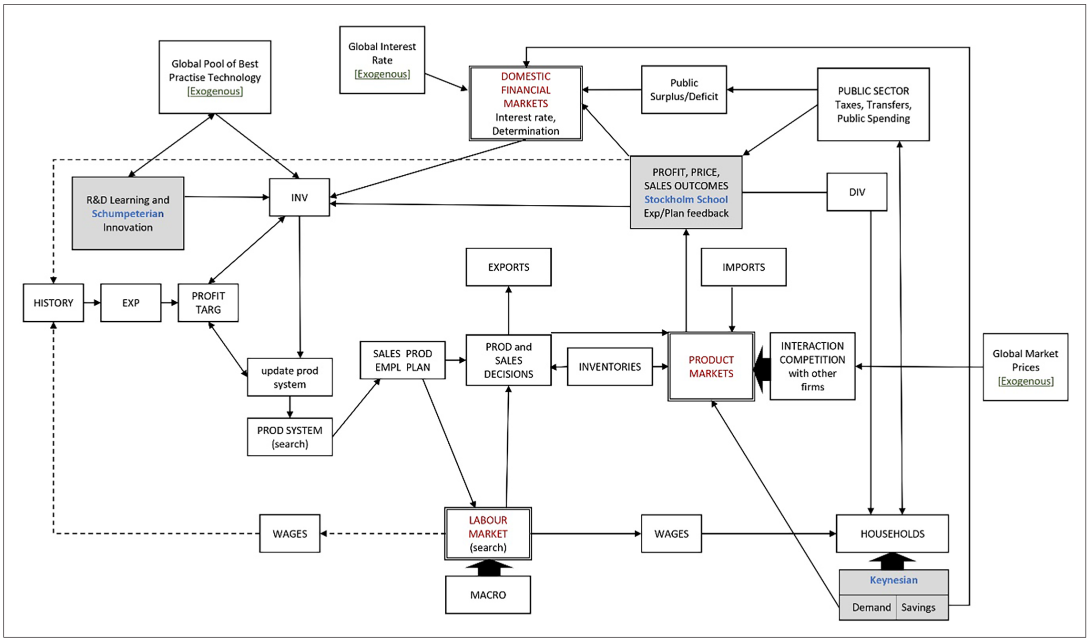

Figure 1 Internal decision structure and interfaces with other firms in three markets of MOSES firm module.
Source: Modified version of ***Figure 1*** in ***Eliasson (1976b)***.

is of courase reflected both in the manual of ***Eliasson (1976b)*** and in the original preudocode documented in ***Lindstenz (2023)***.

Figure 1 illustrates how each business system (firm) relates to the external market world. Shaded blocks tell where Stockholm School expectations (Wicksell), Keynesian demand, and Schumpeterian entrepreneurs enter. ***Table 1*** explains the principles of entrepreneurial entry induced Schumpeterian *Creative Destruction,* and the core dynamics of the MOSES model economy. The complexity of the internal dynamics of one business agent depicted in ***Figure 1*** is sufficient to tell that the agent is neither in full control of its internal economy, nor in control of its market environment composed of all other agents and Government. Simon's bounded rationality prevails universally and forever.

3.5. Empirical credibility requires relevant model specification before estimation begins

Besides being modelled bottom up on observed decision practices of business agents, and their known access to data (as discussed in the previous sections), a priority of the MOSES project has been that it be (1) a general representation of the market dynamics of an advanced industrial economy, and (2) empirical, and *in that order*. That ambition necessitated an agent and market selection based, initial state dependent and therefore highly nonlinear model composition. *Initial state dependence meant that the model economy must be "empirically" positioned initially before theoretical analyses begin*. For obvious reasons our choice was to implement the model on Swedish data.

Ponder the following model: $Y(t)=F(X(t), Y(t-1)) + \varepsilon (t)$, where ε is a stochastic factor of sorts. $Y(t)$ is a vector of dependent variables to be explained, $X(t)$ the explanatory variables, and $Y(t-1)$ a vector of lagged dependent variables. In nonlinear initial state dependent models $\{X(0), Y(t-1)\}$ represents that initial state. *The empirical evidence brought together in composing the MOSES model and accounted for in the previous text tell that nonlinear initial state (history) dependent models are in principle unavoidable in empirically relevant economic modelling of the longer term, and that the short term is very short in a model that runs by, and feeds back agents' market experiences by quarter*.

The standard assumption in econometric applications is (1) that we have got the specification F() right, such that the {ε} are independent of all X and lagged Y, [15] (2) that initial state measurements are of sufficient quality to warrant the assumption that any measurement errors are small and not systematically related to the {ε},[16] and (3) that these model assumptions hold for both the estimation period and the future period for which the estimated model is applied, for instance to forecast. *Micro simulation mathematics in principle allows modelling to come close to that ideal without compromising analytical/theoretical tractability*. Another problem is that estimation difficulties increase with the relevance of the specification (see Sect.3.8 below).

3.6. The partiality predicament

It is important that {ε} includes no systematic component that explains some of Y, leaving something to learn from studying the {ε} (***Samuelson, 1965***). If it does the specification of F() should be expanded to account for that. The point made is that microsimulation is the perfect method to accommodate such expansions both for general theoretical analysis and empirical modelling. We nevertheless recognize that however complex the F() becomes, it will always be partial in some respects, and more or less violate the above assumptions. The stochastic characterization of estimated parameters becomes dependent on this misspecification. The MOSES model is however a perfect design to minimize this problem, in that it is quite general to begin with, but also that, for each experiment (and mainly because of its modular design), the "master model", maintained as a "general platform" for experiments, can be customized to minimize the partiality problem in each application.

Alfred Marshall is credited with coming up with the idea of *partial analysis* and that the economist can say something empirically meaningful under the *ceteris paribus* clause of holding some endogenous circumstances constant. That helped usher in strict formal analysis of clearly circumscribed problems in economics. There are however limits to how far one can go by invoking the ceteris paribus clause without engaging in nonsense economics.

Partial models, used to interpret complex interdependent real problems, provide interesting illustrations. See for instance section 4.4.3. The MOSES model therefore is a serious attempt to minimize the partiality dilemma, and a calibrated MOSES model can in prinicple always be used as a "docking station" for partial models to test for the biases that come with artificially holding endogenous variables constant.

3.7. Model autonomy

All micro based macro models I know about are static in that they neither allow for sequential (periodic) feed backs of ex ante - ex post differences, for instance business mistakes, nor allow agents to learn from the information that is embodied in their mistaken expectations to improve next period plans (learning). Such micro simulation models are neither *autonomous* in the sense of ***Haavelmo (1944)***, nor stable over time, and thus in principle dynamically mis -specified. Even though this deficiency may not matter for (very) short term "static" projections, MOSES simulations beyond a few quarters tell that the consequences of such misspecifications often begin to cumulate. Since the ambition of the MOSES project was to come up with an autonomous model that would be useful for historic counterfactual studies ("What would have happened if instead …***Eliasson, 1976b***) this problem, typical of selection based initial state dependent models, had to be squarely faced. But autonomy is a complicated requirement, and we soon discovered one problem that was common to all our long term simulation studies, namely that autonomy in a model economy self-coordinated by competing market agents required that structural diversity be endogenously maintained over time (***Eliasson, 1984***; ***Eliasson, 1991b***; ***Eliasson, 1991a***; ***Eliasson, 2023a***). Without entrepreneurial entry of innovative firms markets eventually stopped functioning. Not only did competition cease, but structural diversity was reduced because of exit, and often to the extent that the entire model economy became

15. And preferably relatively small. If not, the estimated parameters will still be unbiased but their precision will suffer.

16. This happens to be a strong assumption for MOSES type nonlinear models in which seemingly insignificant systematic errors of measurement sometimes cumulate into major economy wide occurrences. Such occasional incidences of deterministic chaos or genuine unpredictability should be considered considered a real life concern.

increasingly unstable and collapse prone. This is probably the best example of how the MOSES model economy has been constantly empirically validated by identifying the origin of unfamiliar economy wide behavior (or surprise economics ***Eliasson, 2018***), and if found empirically unreasonable, caused modification of model specifications.

By embracing the micro simulation method, we have made it possible not only to upgrade economic model specification) such that the independence of {X, Y(t-1)} and a stochastic {ε} will become increasingly more empirically reasonable. The standard prior assumption that F() is not dated to the historic data on which it has been estimated, but also valid for both counterfactual studies on that historic period, and predictions for another chosen, perhaps future period , can be made more plausible. In addition we have taken a serious step in integrating economic modeling and measurement. With that the empirical relevance of prior model specification (of F()) becomes of supreme importance, making all models (necessarily) *problem dependent*. With F() customized to address a defined *decision problem,* and the empirical credibility of F() conditioned by the empirical relevance of the priors that have gone into that customization of F(), the decision maker who uses the model, and who might have designed the model, therefore must also know its properties such that *s/he is able to interpret simulation results in terms of the internal artificial reality of the model* (See Section 5). For you, as a decision maker, the model design you use defines your understanding of the decision problem you are facing. This is the way ***Simon (1955)*** and ***Simon (1957)*** defined bounded rationality. ***Eliasson (1992)*** uses Simon's concept to define the limited understanding of any decision maker, be it MOSES firm managers or policy makers using MOSES to understand the economy. *This problem becomes more difficult if you want to convince an outsider of the empirical credibility of your understanding*, and by implication of your simulation results (See further discussion in Section 5).

Assumptions (1), (2) and (3) therefore integrate the *economic principles underlying the empirical model in*the sense that relevant circumstances of the decision to be taken have been accounted for to the extent that other factors ("safely") can be assumed to affect F() as independent stochastic noise.[17] *The strategic underpinning of the MOSES project therefore is that micro to macro modelling embodies the potential to move specification of the model as close as possible to satisfying the above assumptions,* and by far much closer than is the case with construed macro or constrained static equilibrium models, and that today *mathematical simulation (a) makes general theoretical analysis of complex micro based macro models possible using numerical methods, and frees the analysts of the limitations of conventional mathematics.*[18] Of particular importance is the possibility of overcoming the partiality predicament (Sect.3.6), that will be further exemplified below (Sect.4.4.3). Computer based simulation mathematics thus overcomes many difficulties of complex formal analysis. Second, (b) the micro to macro or microsimulation method allows efficient use of available micro data, that is left unused in artificial statistical aggregates, a point made long ago by ***Orcutt (1957)*** and ***Orcutt (1960)***. Micro simulation modeling thus not only is a design to endogenize aggregation over explicitly, and more realistically modelled markets than the extreme assumptions about markets underlying macro models and equilibrium models.[19] It also (c) offers a *design potential to increasingly satisfy the stochastic assumptions (1), (2) and (3) above on the properties of {ε}, needed for* the parameters of the model Y(t)=F(X(t), Y(t-1)) + ε (t) to be effectively estimated. *Computer based micro simulation mathematics* thus offers *a method to integrate sophisticated general economic theorizing with economic measurement* that has yet to be taken full advantage of.

17. There is an intriguing correspondence to the distinction between risk and uncertainty. ***LeRoy and Singell, (1987)*** argued that ***Knight (1921)*** had in fact formulated an interesting theory of the firm, in that he defined entrepreneurial competence as a mental capacity to convert an uncertain situation into one of (subjectively) calculable risks, that s/he was prepared to act on.
18. ***The 1965 edition of Allen (1956)***, the math text referred to by generations of economists, for instance, has nothing to say on non linear initial state dependent models, except for a passing reference to ***Goodwin (1951)***, which is surprising, since already in 1965 the general empirical understanding of economic reality must have been that economies are nonlinear, and selection and initial state dependent..
19. Since these aggregation assumptions concur with the assumptions made in static general equilibrium analysis, these two examples of economic orthodoxy, including derivate models, warrant the claim I have made above (and in ***Eliasson, 2023a***) about *economic orthodoxy being economics without markets*. To the extent that dynamic markets can be assumed to matter for macro, economic orthodoxy should therefore be avoided.

3.8. Calibration as second best

There is a corollary to the last statement, namely that to satisfy the condition of independence of F() and factors not recognized, raises model complexity in practically all decision situations. While the microsimulation method makes general (numerically based) theoretical analysis possible, with functional complexity comes mounting difficulties of parameter estimation. The more empirically relevant the model design, the more likely the desired stochastic assumptions of {ε} will be satisfied, but the more difficult it will be to determine the stochastic properties of the estimated /calibrated parameters. Even though availability of data, improved measurement of initial conditions and computer capacity may eventually overcome this dilemma (***Klevmarken, 1978***; ***Klevmarken, Anders,2022, n.d.***), this doesn't solve the current problems of MOSES estimation, or for that matter of all agent based non ergodic models (***Richiardi, 2017***; ***Grazzini and Richiardi, 2014***). Hence, to be up to its ambition to be empirically relevant, the MOSES project has had to do with *calibration* as a second-best approach to estimating its parameters.[20] *Calibration*, as I define it, *differs from estimation in that the uniqueness and the stochastic properties of the calculated parameters have not been determined*.

Ordinary least squares (OLS) applied to linear models give consistent estimates that are asymptotically normally distributed. MOSES is far from linear and its loss function therefore highly complex and not analytically determinate. It should however be possible in principle to figure out, using numerical methods, what kind of estimates that will be obtained when the sum of squared distances between simulated and control variables is minimized using the computer based calibration program of ***Taymaz (1991b)***. This loss function in MOSES is however very complex, and its selection features mean that minimization may result in several local minima. This problem, however, also afflicts standard estimation methods, and the only way to decide which parameter settings to choose is to do what we have already done, namely to validate the calibrated parameters against other exogenous facts.

On this ***Hansen and Heckman (1996)*** state comfortingly that "there is nothing sacred about the traditional loss functions in econometrics associated with standard methods, like OLS, except that they can be "rigorously justified", producing, for instance, in linear models, consistent parameter estimates that are asymptotically normally distributed. So far, we are therefore sufficiently satisfied with the set of calibrated parameters using the method of ***Taymaz (1991b)*** and ***Taymaz (1993)*** to refer to results from MOSES simulations as relevant for the dynamics of a *Sweden like industrial economy.* The question is rather what steps need to be taken, if needed, from there, and before data and computer capacity have become available, to obtain a sufficiently rigorous representation of the Swedish economy? My argument on this has been that few economy wide models satisfy that requirement, being both mis specified, and failing to provide a convincing argument that their ε (t) have the required stochastic properties.

On this MOSES model validation offers the following advantages.

3.9. Consistent calibration

The specification possibilities offered by the microsimulation method have made it possible to substitute direct measurement for parameters in many places (initial state, bankruptcy law and exit), reducing the need to estimate for instance exit functions and distributed lags etc, thus also reducing the number of parameters to be estimated to the critical couple of dozens that regulate market self-coordination dynamics. On them we have found that they have stayed quite close from model upgrade to model upgrade and from changing from the manual calibration method of ***Eliasson (1978a)***; ***Eliasson (1978b)***; and ***Eliasson and Olavi (1978)*** to the ***Taymaz (1991b)*** and ***Taymaz (1993)*** computer calibration method. We take that as a comforting sign of *consistent calibration* (for details see Appendix).

The annual Planning Survey has so far produced panel time series data of individual firms that can be used each new year together with national accounts (NA) statistics, as fresh test data. The most obvious procedure would be to retest the model each year as new data becomes available. Under the assumptions (1), (2) and (3) above, and that the specification of the model holds for each

20. An alternative second best two stage method that we have considered is to estimate a linearized approximation of the MOSES model, which might in practice turn out to be one of its component special cases, such as a Leontief – Keynesian sector model, and to calibrate the full MOSES model under the constraint of this estimated "reduced " linear mapping of the model.

future period added, one would then expect new calibrated parameters to cluster within a narrowing interval. If supported from year to year this test would be as good as any estimation procedure, and with increasing confidence warrant references to the Swedish economy.

Finally, model specification will never be general enough to hold forever, and calibrated parameters may eventually begin to stray off in new directions. This should prompt us to look for structural changes in the real economy that the model has not picked up, and to modify its specification. One example of this validation method is that when the model economy began to exhibit severe instabilities in long run simulations, and especially when some of the critical market parameters were changed from the calibrated values to speed up market arbitrage (***Eliasson, 1984***; ***Eliasson, 1991b***; ***Eliasson, 1991a***; ***Eliasson, 1991c***). This is not a desired property of a good model. The reason, we soon discovered, was that with entry shut off structural diversity deteriorated rapidly when faster market arbitrage, notably in the labor market, forced inferior firms to exit faster and faster. Structural diversity and systems stability were restored when the ***Hanson (1989)***; ***Taymaz (1991a)*** and ***Ballot et al. (2006)*** endogenous entry algorithms had been introduced in the MOSES economy (***Eliasson, 1991a***). In Section 6, I discuss extensions of MOSES specifications , and why, because of its modular design, some of these design changes may not much affect the parameters of the core market innovation and competition machinery.

Empirically well-grounded a priori specification with the ambition to satisfy assumptions (1), (2) and (3) thus should always come before estimation. It is therefore bad scientific procedure to throw in a standard model without comment except perhaps for a reference to its general theoretical familiarity. *The basic assumption of MOSES calibration has been that we have got the specification right, such that the simulated results can be confidently interpreted in terms of the internal artificial reality of the model economy* to support the decision for which it has been customized. If the specification is good and parameters reasonable you should feel confident in the simulated results. Micro to macro or micro simulation modelling thus offers the advantage of both allowing and forcing the economist to come up with empirically well-grounded prior specifications that are as close to satisfying assumptions (1), (2) and (3) as is possible. (Since the modular design of the MOSES model technically simplifies a customized design of the model to be consonant with the decision problem addressed, a carefully calibrated MOSES model in no way is less empirically credible than a perfectly estimated but falsely specified model, for which a careful analysis of the biases of an unsatisfied assumption (3) has not been documented. Both rest on a priori assumptions that must be compared and argued separately, and before estimation, and therefore suffer from the same problem. The wrongly specified partial models discussed in Section 4.4.3 are examples).

3.10. Arriving at an empirically relevant representation of a Sweden like industrial economy

We argue (1) that MOSES specification is as empirically relevant as has been possible to achieve for an advanced industrial economy, and that its original modular design has made gradual expansions possible. Second (2), the specification of the MOSES model, trimmed of detail down to its core micro-market- macro dynamics, as specified already in ***Eliasson (1976b)***, has allowed the general theoretical analyses of its dynamic properties commented on in the first two sections of this document. Third (3), in setting MOSES up for simulation studies it has been loaded with initial state data of production agents (firms and divisions in large firms) from (3a) a separate so-called Planning Survey conducted annually by the Federation of Swedish Industries. The firm data (3b) in turn has been integrated stock flow and micro to macro consistently with the official National Accounts (NA) for Sweden. The latter serves as a size reference for the model economy. How this MOSES Data Base has been composed for 1982 is described in detail in ***Albrecht (1992)***. (*1) and (3) are sufficient to refer to MOSES as representing a Sweden like industrial economy*. The MOSES model, however, also claims to have the potential to represent the sequential dynamics of the real Swedish economy over the longer term. That, however, also requires (4) that a couple of dozen critical parameters that regulate the intensity of market competition, and the period to period Stockholm School dynamics of the model economy be properly estimated.

Already in ***Eliasson and Olavi (1978)***, about 20 so called "time reaction parameters" were identified that regulated either the longer term growth trends of the model economy, or the cyclical variations around those trends, or both. Since micro distributional data were collected in the Planning

Survey it became gradually possible also to test the model's capacity to generate historic distributional patterns (see ***Taymaz, 1992a*** and Appendix).

Over the years a three-step calibration/estimation procedure for these parameters has been developed:

A. Calibrate a selection of parameters against a selection of test variables, using the distance (sum of squared deviations) minimizing methods of ***Eliasson (1978a)***; ***Eliasson (1978b)***; ***Eliasson and Olavi (1978)***; ***Taymaz (1991a)*** and ***Taymaz, (1993)***, holding the exogenous variables at their observed values (notably foreign prices, interest rates, and productivities of best practice globally available technologies. On the latter see the IVA project in Section 4.2).
B. If several different calibrated parameter combinations with roughly the same fit are obtained, exclude obviously false ones by prior judgement, and regard the others provisionally as empirically acceptable, even if lying within a wide "confidence interval".
C. Keep recalibrating the model as under A and B as new test data arrives and take it as a sign of "consistent calibration" if the calibrated parameters do not change much or converge into a multi-dimensional cluster of a priori reasonable values.[21]

These are principal criteria that have been intuitively followed over the years, but that remain to be worked out more precisely mathematically, something that makes sense, since the stochastic assumptions (1), (2) and (3) above are the same as those of standard estimation methods.

Our experience has been that a dozen calibrated parameters that regulate the core market dynamics of the entire model economy, represented by about the same number of macro test variables, as shown in ***Eliasson, 1976a***) and in the Appendix, have stayed reasonably constant between both model generations and data base changes. The early manual method described in ***Eliasson (1978a)***; ***Eliasson (1978b)***; ***Eliasson and Olavi (1978)*** did not allow a wide search for good fits, so we could not be sure that the empirically correct combination of parameters did not lie elsewhere. With ***Taymaz (1991a)*** and ***Taymaz, 1993*** computerized calibration method a much wider search became possible, using new test data. We were then happy to find that the new core model parameter estimates stayed roughly the same as the old estimates, even though the new estimates were obtained for a much-expanded model. Fortunately, we did not find any outliers with good fits.[22] With a sufficiently long panel data base from the Panning survey an even larger number of parameters should make it possible to fit MOSES simulations to test variables representing distributional characteristics of firms.[23]

3.11. Initial state - the planning survey

Empirical studies on the MOSES model require that a full scale data base for the initial year be set up. This is a major statistical job, that was needed for the cost benefit study of the industrial support program of the 1970s, which also had a generous budget (see Sect. 4.3). We have, however, developed a method to keep the model constantly ready for empirically less ambitious studies. From a carefully prepared initial state, for instance the one for for 1982 (see ***Albrecht, 1992***), the model can be simulated forward "guided by" known exogenous variables. It can then be reinitiated by substituting the most recent firm data from the annual Planning Survey for the simulated firm data, within the simulated macro frame of the model. This procedure makes it possible to keep the MOSES model constantly ready for "semi-empirical" simulation studies that require an updated initial state data base. For principal analyses of this kind it is not necessary to have access to new Planning Survey firm data. Model simulations generate complete micro to macro and stock flow consistent initial states for

21. We have considered using different small samples of the historic test data base to calibrate several parameter constellations and use them to compute a "confidence range", and then hope for continued calibrations on new data to result in narrowing the range within which the calibrated parameters gradually would converge. The principles of that testing, and performing the tests, however, remain to be worked out.
22. A critical test arrived with ***Taymaz (1999)***; ***Eliasson (2001)*** and ***Eliasson and Taymaz (2001)***, in which a sophisticated capital market financial regime was substituted for the earlier simple industrial banking system. Financial cost considerations were now being integrated with product and labor market price expectations *within the business plans of individual firms*. Demands on computer capacity, however, had now escalated such that we could not evaluate the consequences using repeated long run economy wide simulations of the entire model on the ***Taymaz (1991a)*** calibration program.
23. Some of that has in fact already been attempted. See (***Eliasson, 1985***).

each future quarter. For theoretical studies these artificial initial states are in fact to be preferred to a complete reinstallation of MOSES on a new data base, since then all errors due to inconsistencies between Planning Survey firm data and official National Accounts will have to be fixed again. The simulated initial states can also be customized for the study to be done by varying exogenous variables or parameters etc such that a desired initial state is obtained, for instance a balanced macroeconomic situation to eliminate the effects of cyclical factors over the longer run.

The MOSES model generates complete initial states for every quarter during a simulation. Technically it can therefore generate data of immense detail "on demand". It has however not been designed for predictions of such detail. A detailed short term "static" simulation, one or perhaps even two years ahead, might make sense, because then the sequential feedback dynamics mentioned above has not yet much affected the outcome.[24] Most empirical microsimulation studies I know about are "static" in that sense, and aim for distributional predictions of great detail, for instance the distributional effects on disposable income of a modification of the income tax and rent subsidy system, holding incomes unchanged. This would however be a misspecification for anything beyond the very short run, and MOSES experience from dynamic simulations does not recommend such static calculation methods. Since the MOSES model has only been calibrated on a selection of critical target variables that are directly affected by the feed back dynamics just mentioned, but routinely "predicts" many more, the principal problem of how to interpret the latter remains. Since these secondary dependent variables are tightly (linearly) related to the critical variables against which the model has been calibrated, difficult to understand extreme behavior of these variables will therefore, as a rule, be associated with extreme behavior of the test variables. Some such extreme output from model simulations tabulated in the policy study ***Eliasson (1992)***; ***Eliasson (1992b)***; ***Eliasson and Taymaz (1992)*** was criticized. On close inspection, however, the extreme model behavior brought up for discussion had been generated by the extreme policies the model economy had been subjected to (see further Postscript appended to the republished study in this Anthology).

3.12. Sensitivity tests

Testing long term economy wide behavior of the MOSES model economy for sensitivity to external conditions, initial state measurement errors or parameter changes, using Monte Carlo experiments, is the final validation stage, and became routine practice in pace with the rapidly increasing computer capacity (see for instance ***Eliasson and Taymaz, 2000***). Such tests frequently led to changes in model specification, and made us look for inconsistencies in data inputs, and suggested modification of some calibrated parameters. An absolute requirement set up for the MOSES model has been that the economy wide behavior of the calibrated version stays viable over the very long run. Collapse like behavior of the calibrated version over the very long run has always been a cause for concern and made us identify the reason. The most important example of this theoretical or empirical validation (See Section 2.3) was that the MOSES economy tended to exhibit strong fluctuations and collapse like behavior in some experiments. Sometimes it occurred when we allowed the model to run into the very long term in a short-term empirical experiment to see what happened. Sometimes we provoked the model by changing its parameter setting to force markets to reduce inefficiencies. The latter were theoretical experiments conducted in response to academic criticisms that we had not properly clarified the equilibrium properties of the model. We then found that a static market clearing equilibrium state of the model was unattainable, and for good theoretical reasons (***Eliasson, 1991b***; ***Eliasson, 1991b*** Sect.2.3 above), but also that collapse like behavior of the model economy should be considered normal under extreme conditions. The typical reason was a rapidly deteriorating diversity of structures and the convergence of a shrinking firm population towards similar ("representative") firms, making markets dysfunctional. Turning on a closed down entry module and endogenizing entry remedied this model deficiency.[25] An important consequence of these theoretical experiments was that we started to study Planning Survey firm data more closely, and discovered that Swedish manufacturing had experienced a deteriorating structural diversity for many years due to reduced entry of new firms.

24. To be noted is that many (perhaps all) micro simulation or computable general equilibrium models are static and lack market feed back dynamics, and therefore do no more than that.
25. The reason for closing the original exogenous entry module (see ***Bergmann et al., (1980)*** was a critical academic seminar that had strongly advised that entry was of little interest in macro economic studies. Note that this was during the late 1970s.

We alerted Swedish policy makers and academics to the macroeconomic economic risks inherent in that development, but with mixed success (see Section 5.4).

Calibrated parameter estimates judged to be empirically acceptable, after having passed the above test criteria, in my view makes the MOSES model a dynamically and empirically acceptable representation of a *Sweden like industrial economy*. There is therefore all reason to take simulated outcomes seriously as *occurrences that may take place in a Sweden like industrial economy under the circumstances defined by simulation experiments*.

3.13. Empirical validation, model maintenance and survival

This section has been concerned with the validation of the MOSES model economy for empirical studies, in practice to make it represent a *Sweden like advanced industrial economy*, but ultimately , when proper parameter estimation has been achieved, to credibly represent the Swedish economy. Even the lower ambition level is sufficiently demanding on database quality to cause "maintenance" problems. Yet the MOSES model had survived for fifty years by 2024 and exists today in several operationally active versions that have been set up for particular applications (see Appendix). Let me therefore conclude this section by explaining how.

A master version of the MOSES model is kept installed on at least one database. It has been regularly calibrated. The model specification has now and then been updated and validated. The Appenix shows the history of MOSES progress in that respect. With time, however, and depending on what problems are addressed, a more radical updating of specifications will be needed for serious empirical studies (see section 6). Even though older versions of the model and old data bases retain sufficient structural and dynamic market characteristics to make them interesting for general studies of the properties of advanced industrial economies, with time the characterization "Sweden like" gradually loses its validity. Thus, for instance, the role of markets in long run macroeconomic evolution is still unique to the MOSES model economy. Simulation studies on a Sweden like industrial economy during the first half century after WWII will keep being historically interesting, especially since it is only a budget question to update the database and recalibrate the model (see section 6). Let me therefore explain how MOSES has been kept operationally active for general theoretical, but also empirically interesting general analyses of agent based macroeconomic market dynamics.

3.13.1. MOSES model maintenance

Since each MOSES experiment generates a complete Micro Macro (MM) and stock flow (SF) consistent initial state database for each future quarter it is not necessary to compile a new data base (a major statistical effort) for the type of studies we are currently focusing on.[26] The latest calibrated version of the MOSES model is based on the 1997 database but has been moved (simulated) forward in time along known later exogenous variables to position the model on a relevant initial state for principally interesting studies.[27] Just to exemplify: One such principally fundamental study is outlined under §7 in Section 6.2. It requires only minor modifications of the extended version of MOSES used by to study the global diffusion of technologies between globally interacting cloned MOSES models. Such a study will probably be based on the 1982 database, extended with the capital, stock and financial derivatives markets introduced with ***Eliasson (2001)*** and ***Eliasson and Taymaz (2001)***.

3.13.2. Empirical credibility requirements differ depending on type of analysis

While empirical credibility requirements differ depending on whether we are carrying out (1) principal theoretical studies that can be generalized to a Sweden like industrial economy or conducting a (2) politically sensitive economy wide cost benefit analysis like that on the industrial support program of the 1970s/80s (Section 4.3), a data base simulated forward on known exogenous variables would be

26. In addition, by varying the exogenous variables these initial states can also be customized. Remember, however, that the market dynamics of the MOSES model economy makes it impossible to generate a static equilibrium initial state. It doesn't exit as an operating domain of the MOSES economy (see further Section 1.3)
27. Until around 2005 we had the option to substitute the most recent Planning Survey firms for the endogenously generated firms, and thus avoid having to compile a full Micro to Macro and Stock Flow consistent NA data base for that year.

satisfactory for the first type. A full-scale economy wide cost-benefit study, on the other hand, would require special financial support to build a new complete database. The MOSES database has been completely updated to a new initial year several times (see Appendix), the most thorough one being for 1982 (see ***Albrecht, 1992***), because the empirical ambition of the study then demanded it. That upgrading was then also paid for by the research contract. Those contracts have in fact been critical for the continued survival of the MOSES project.

3.13.3. Model customization and validation

Validating the MOSES model has taken place in several steps. Let me summarize (For technical details, see Appendix). The basic, and all dominant empirical input in the MOSES model is its *specification*, which both organizes all data crunched through the model, and defines *the artificial reality in terms of which simulation results are interpreted*. The MOSES model has been designed bottom up based on observed (in ***Eliasson, 1976a***) business expectations formation and planning and decision practices.

3.13.3.1 Specification

As has been the case throughout model work the most important and novel specification is *the algorithms that control how markets organize interactions between agents and thus self-organize the entire economy. Calibration or estimation of the parameters of those market algorithms are thus conditioned by that specification and the measured initial state*. Inquiries however often require customization to make the model conform to desired stochastic assumptions (see Section 3.5). As I have emphasized, the MOSES model is not a general all-purpose model, but by integrating several familiar partial models onto an agent-based market platform (see Section 1.1), it has become sufficiently general to allow for interesting problem dependent customization. The ambition therefore becomes to have a satisfactorily calibrated *master version* constantly ready for such customized applications. This master version, at the same time, has become instrumental for general economic studies using mathematical simulation or numerical methods predicted already by ***Koopmans (1957)***.

3.13.3.2 Data base

MOSES type nonlinear initial state dependent models always require a basic empirical input. In MOSES that is the statistical representation of the initial state, which is a complete micro to macro stock flow consistent National Accounts (NA) representation of the Swedish economy for that year, a critical input being the Planning Survey firms for that year. The most carefully prerpared initial state documentation for MOSES is for 1982 and represented a major statistical effort (see ***Albrecht, 1992***). Since the MOSES model generates complete such initial states for each future quarter, conditioned by known future exogenous variables, empirically “semi relevant” initial states can in principle be made available for any future quarter, and the model experiment started on the latest available Planning Survey data, or on the firm data generated endogenously for that quarter.[28]

3.13.3.3. *Estimation/calibration*

Calibration or estimation are conditioned by the specification of the model and the initial database. It was first done manually according to the ***Eliasson (1978a)***; ***Eliasson (1978b)***; ***Eliasson and Olavi (1978)*** criteria,[29] then by the sophisticated ***Taymaz (1991b)*** and ***Taymaz, (1993)*** computerized calibration program, all the time paying attention to the long run behavior of the model. Early on we identified around twenty parameters that regulated (1) long term trends, (2) cyclical fluctuations around that trend and (3) both, of a roughly equal number of macro test variables. We have also experimented with a wider set of parameters to test for the capacity of the MOSES model to generate distributional characteristics (Se section 3.10). These calibrated critical parameters have stayed very close from calibration to calibration. We consider this a satisfactory test for *consistent calibration*.

28. Technically that synthetic initial data base is to be preferred, because the model generates Micro to Macro Stock Flow Consistent data for each quarter, while a new empirical installation demands that inconsistencies between different data sources be “eliminated”.
29. Very few computer based calibration programs were available at that time.

3.13.3.4. Final validation

For obvious reasons the MOSES project will never be finally concluded. Fortunately, its original modular design and empirical ambition resulted in a general specification that naturally lent itself to further improvements. Those improvements are of two kinds; (1) *design modifications* to correct undesired economic systems behavior of the model ("theoretical validation"), that I address in this section, and (2) *expansion* to account for basic structural changes in the economy to keep MOSES relevant as a representation of a Sweden like economy (see Section 6).

Theoretical validation aims at making the model *behave properly over the very long term* (see Section 2.3). That instance of model validation has been critical in that it was early discovered in ***Eliasson (1984)*** that long run macro economic growth could not be sustained if the model economy did not endogenously maintain a constant upgrading of its diverse production structures and the heterogeneity of its firm population, both associated with an advanced industrial economy like the Swedish one. Since this was an empirical property of the Swedish economy, but not of all industrial economies, the specification of its parameter settings had to be done accordingly. Monte Carlo experiments to test the sensitivity of economy wide long run behavior to changes in behavioral algorithms, time reaction parameters and initial state data, have been routinely conducted in pace with the advance of computing capacities. An intriguing" problem" has been the MOSES economy's constant refusal to converge on a steady state equilibrium path, but rather into a wide region bounded from above, but not excluding the possibility of near complete systems collapse, and for good reasons we have found (see Section 2.3).

4. Empirical studies

The MOSES model was frequently (and sometimes too early) used for empirical inquiries, even into sensitive political economic problems, and often on request by government committees or public authorities. Its micro specification for better macro analysis was considered an advantage over available sector models. The possibility to describe *in familiar empirical categories* what was going on during simulations within the internal artificial reality of the model appealed to Government committee members. More important, MOSES would not have survived without those contract jobs. They made it possible to carry out costly new data collection, that I doubt would have found alternative academic financing.[30] From 1989, when MOSES had been safely installed on a PC, the crippling computing costs were also finally overcome.[31]

The interest in MOSES specification expressed by government institutions and even firms, but not by far to the same extent in academia, is a fact of considerable academic interest, that warrants some comments. Since the MOSES model integrates several familiar partial models, and since many of its "surprising" dynamic properties largely depend on how markets integrate those partial models, it represents a *cognitive theoretical design* that we have frequently called in for *complex general economic reasoning*, not least to help pay attention to side effects of political interventions that are neglected by prior design in the common repertoire of partial models. This is particularly so when it comes to the role of dynamic markets populated by autonomous agents with own agendas in understanding macro (see Sect. 5). Results from simulations could therefore, as we will see below, be comprehensively presented in familiar and observable terms, or categories making up the internal artificial reality of the MOSES model economy. Avoiding abstract concepts such as elasticities or other mathematical categories that much too often have no empirical meaning to non – economists has helped widen the audience to non-professionals. This use of the MOSES model also explains our early concern with empirical credibility, and our emphasis on empirically relevant specification. A principally important example of this is that "labor market" models that lack explicit markets do

30. Between 1977, when IBM left the MOSES project and 1989 computer costs were solved by various improvisations. For several years our "sister institute " SNF in Bergen, Norway allowed us to use their option on the DEC mainframe computer at the Norwegian Business School for free at night. Later MOSES was installed on a Prime minicomputer at the Federation of Swedish Industries that again allowed us free access to the computer at night. The transfer of the entire MOSES model between IBM APL and DEC APL to PRIME APL, and then to a Windows PC based APL system has involved no minor efforts. The transfer from IBM APL to DEC APL was critical for the survival of the MOSES project. Jim Albrecht had however found that Columbia University had deverloped a special translation program to do exactly that for its administrative computer system, that we were allowed to use for free.

31. IBM had left the project already in 1977.

not provide credible advice on unemployment policies. Policies aimed at changing relative wages or lowering unemployment are much too often based on empirical research that neglects the economy wide effects of market agents' own reactions. When markets in MOSES experiments were allowed to play a role in the analysis, results came out very differently, and not as expected. It became interesting to ask whom to believe; the theoretical predictions of MOSES, or the "empirical" results from a mis specified model (***Eliasson, 2023a***).

Since the documents to be summarized below are loaded with necessary empirical and technical detail and often published as books, it has not been possible to put together a selection of "articles". I have done my best to summarize with a focus on the role of MOSES and microsimulation methods.

4.1. Taxes, tax wedges and unintended biasing of economic systems outcomes

No serious study on the Swedish economy should be conducted without due consideration of its enormous tax and transfer system, that lodges deeply and heavily in the self-organizing price mechanisms of the markets. While the first two sections of this Anthology have been devoted to clarifying the principal functioning of the self-organizing market dynamics of the model economy, empirical applications were the ultimate ambition. For that reason, the complete Swedish tax and transfer system was introduced in the MOSES economy already with ***Eliasson (1980a)***. It was there demonstrated how tax wedges in the price system bias long term allocational outcomes, why the same tax take to finance the public sector and transfer payments using a payroll or a value added tax had different distributional and macro-economic consequences, and how a transfer from the one to the other incurred social costs on the economy in the form of a permanent loss of output. Simulating the macro-economic effects of corporate taxes and fiscal depreciation rules ***Eliasson and Lindberg (1981)*** demonstrated why major investment mistakes caused by tax wedges, or misdirected subsidies caused little harm to the macro economy if identified early and promptly closed. The large macroeconomic, "social" costs were incurred if production was carried on in the mistaken investments, a consequence that became all too familiar in the industrial support program of the 1970s and 1980s (see Section 4.3 below). Without the complete tax and income transfer module introduced with ***Eliasson (1980a)*** the next few empirical studies would not have been possible.

4.2. Technological change, economic growth and employment – the IVA study

In 1977 I became the director of the Industrial Institute for Economic and social Research (IUI) and took the MOSES model with me. The same year IUI teamed up with the Swedish Academy of Engineering Sciences (IVA) to clarify, on contract with the Swedish Technical Development Board (STU, a government authority subordinated the Ministry of Industry), the technical and industrial competence endowment of Swedish manufacturing, and by implication the role of new technologies in Swedish economic growth in the past, and for the future. The MOSES model came to be used as a cognitive instrument to sort out different explanations of how the post oil crises stagnation had been caused, and to suggest policy solutions to get the economy out of its distress. As part of this so called "Grand Project", IVA's members, most of them technical directors in large Swedish firms, could be tapped for quantitative information about the historic development of best practice technologies. In addition to being of great interest to the" Grand Project" when interpreted in terms of the model, this data was used both to run historic experiments, and to calibrate the MOSES model.[32] This project provided research results for an international IUI conference 1977 published as ***Carlsson et al., (1978)*** and ***Carlsson and Olavi, (1978)***, and caught the attention of the Directorate of Science, Technology and Innovation of the OECD, which asked for complementary simulation studies on the role of human capital, and education in economic growth, and commercialization competence. Several publications followed (***Carlsson et al., 1979***; ***Carlsson,***

32. Data was collected on the labor productivities of best practice technologies as entered exogenously in MOSES simulations. For exact definitions see ***Carlsson and Olavi (1978)***; ***Carlsson et al. (1979)*** and ***Eliasson (1976b)***.

1972; ***Carlsson et al., 1981***; ***Eliasson, 1979***; ***Eliasson, 1980b***; ***Eliasson, 1981***).[33] This time the main contribution of the MOSES model was improved "cognitive insight" rather than micro to macro quantification. The economy wide micro market format of the MOSES model made the *integration of technology and economics through commercializing markets* a central concern. It kept us from getting locked up in the partial tunnel vision of the linear technology growth drive proposition attributed to ***Schumpeter (1942)*** that had become popular policy among stagnating economies on which Keynesian demand had been found not to work. The story now became, subsidize R&D investment and growth will return. Of course this did not work, since it *neglected the costly complementary commercialization phase of identifying and scaling up technologies, as well as the complementary human capital needed*. We found (see Section 2.1 on competence bloc theory) our focus on a more market minded ***Schumpeter (1911)*** to be more promising. (From the perspective of economic doctrines it is however interesting to observe that the linear Schumpeter of 1942, that grew into the "national innovation systems"proposition of ***Freeman (1974)***; ***Freeman (1987)***; ***Lundvall (1992)***; ***Nelson (1992)*** and ***Nelson (1993)***,[34] also branched out into a neoclassical version called New Growth theory, first formulated by ***Romer (1986)***. This time R&D fueled macro innovation functions created network productivity externalities and then economic growth. From our point of view it is interesting to note that the network externalities are represented in new growth theory models, for instance ***Romer (1986)*** and ***Jones and Williams (1998)*** by an assumed positive macro relationship between a general collective knowledge capital and all other factors of production (an externality, see ***Eliasson, 1996***). Those *network externalities can be simulated on MOSES as an endogenized consequence of financial market resource reallocations* (***Eliasson, 1976b***), *and/or reallocations of the human capital of trained workers* (see Section 4.4.4 below). Without *complementary financial* market and human capital support, we found, little growth should be expected from new technology creation. On the other hand, improved labor and financial market performance, holding technology constant (No change in best practice new technologies) was found to significantly raise macro productivity growth over the medium term, until the reallocation effects of improved market selection had petered out (***Eliasson, 1979***; ***Eliasson, 1981***). Similarly, simulation experiments gave no support for worries about technological unemployment. Job losses in stagnant industries caused by competition from technologically superior firms, that in turn caused a general macroeconomic expansion were compensated for by new job creations, accompanied by a temporary rise in transactions unemployment, as workers moved to new jobs over the labor market. In fact, if markets did not do that job, and/or if defunct producers did not shut down (Section 4.3) the technology induced expansion might fail altogether to come about. A series of MOSES simulations demonstrated that growth and employment outcomes required significant complementary structural change (***Carlsson et al., 1981***). Sustainable long term growth was in general impossible to achieve without significant complementary churning of production structures, increases in investments in new and profitable firms, exits of inferior producers, and significant accompanying movements of workers over the market from low performing to fast growing firms. Again, the labor market had to function as a market for these positive results to materialize. (These conclusions may sound self-evident, and they are, but MOSES simulation results played a role in preventing simplistic (partial) stories from dominating the economic policy discussion in Sweden, and in particular the proposition, pushed by unions, that manufacturing firms with problems should be subsidized to train their workers to be

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33. Another consequence of the OECD relation, only indirectly related to MOSES, was that I was engaged in work done by the Education Committee of the Directorate for Education. Employment, Labour and Social Affairs. They wanted to figure out how the school agenda should be composed to best prepare students for work, notably in the new emerging digital economy, and they were particularly interested in the studies IUI had conducted for the Swedish Government Computer and Electronics Committee in which MOSES and markets to macro figured importantly. On this some publications followed, for instance ***Eliasson (1979)***; ***Eliasson (1980a)***; ***Eliasson (1981)*** and ***Eliasson (1987)*** on the "Knowledge base of an Industrial Economy" and ***Eliasson, 1994*** on "The Markets for Learning and Educational Services" , studies that later became inputs in the design of the OECD PISA project.

34. Independently of, and before Nelson and Lundvall presented their national innovation systems, ***Carlsson & Stankiewicz (1991)*** had developed their theory (a technological system) to explain the *creation* of new technological innovations. As it happened, the technological system, developed as part of the IUI/IVA project, fitted very nicely into the innovation module 2 (in ***Table 2***) of the competence bloc in Section 2.1. Also see ***Ballot et al. (2006)*** (republished in this Anthology), who simulate the macroeconomic consequences of competence bloc formation, or of more or less competent commercializing actors.

capable of "reorganizing themselves from within" without forcing workers to change jobs over the market. The next MOSES project tells a sad story on that theme).

4.3. The industrial support program of the 1970s and 1980s – A model based dynamic economy wide cost benefit analysis

The potential of MOSES for *economy wide dynamic model based cost benefit studies of major policy interventions* in the economy was soon discovered. A contract was offered by the Department of Industry to investigate the potential of the Swedish shipyard and standard steel industries to recover as viable businesses from the deep crises brought on them by the oil price shocks of the 1970s, and devastating Japanese Government subsidizing of its shipyards. (This required both a preparatory analysis of the industry, and setting the model up for quantitative studies. The first part was already available with the IUI study **Bentzel et al. (1970)**, contracted by the Department of Industry, in which I had participated with a financial analysis of the six shipyards (**(Eliasson, 1970)**. We knew that the Swedish shipyards were technologically more advanced, but several of them (the six together making the Swedish shipyard industry the second largest in the world at the time, after Japan), had unfortunately invested themselves into the wrong niche of the oil tanker market. On that **Bentzel et al. (1970)** had concluded that the mistaken technology focus and Japanese competition were not sufficient reason to allow the technologically most advanced industry to go, even though my financial analysis had found the shipyards in a dire financial state because of the competition from the subsidized Japanese shipyards. They would immediately be bankrupted if government subsidies were not forthcoming).

Some years along the extremely costly subsidy path the Swedish Government had embarked upon to save the large Swedish shipyard industry, IUI was asked again to evaluate the program historically, and for the future if it was continued. We were specifically asked to use the MOSES model for quantification, even though it was not ready and empirically properly calibrated for such politically delicate economy wide cost benefit analyses. All Swedish shipyards were however in the MOSES firm database, and we got access to a wealth of firm data, not least the exact disbursement of subsidies by quarter on each shipyard. The study has been documented in detail in **Carlsson et al. (1981)** in Swedish). I devote extra space to this dynamic economy wide cost benefit study because it is principally interesting as an application of dynamic MOSES type microsimulation method, and because it has been subject to an ex post evaluation in **Carlsson et al. (2018)**, that was possible only because all computer print outs had been carefully archived in the Swedish Centre for Industrial History.

(The subsidizing of their shipyards by Japan to achieve dominance in both ship production and global bulk shipping of oil was of course not acceptable, as are not similar attempts by China today. Neither was it very clever of Swedish Government to make Swedish taxpayers subsidize the highest paid workers in industry to produce in practice zero value added for almost a decade, depriving the rest of industry of their work input, and pushing up wages, generally slowing economic growth elsewhere). In **Carlsson et al. (1981)** and **Carlsson (1983)** different alternative ways of distributing the subsidy money (the public budget remaining unchanged) were simulated on MOSES and compared with what was actually decided in the Government budget to be done well into the 1990s under the official prediction of exogenous variables as published in the Government Long Term Survey ("Långtidsutredningen"). The optimal policy turned out to be to terminate the subsidy program immediately, and disburse the subsidy money back to all Swedish firms in the form of a flat rate lowering of the payroll tax.[35] When subsidies were discontinued the shipyards promptly went bankrupt (depleted their net worth and exited), and Swedish manufacturing returned to the previous faster growth trend that the subsidies had forced it off. In the interim period it had however dropped to a lower level of output that had not been recovered at the end of simulations (**Carlsson et al., 2018**). The main reason for that was that the subsidies had both locked skilled workers into zero value added production, depriving the rest of manufacturing of their work input, and raised the general wage level, thus discouraging firms in general from investing and expanding. Shipyard workers were forced into the market when subsidies were terminated in 1985, but in a couple of years they were all (in model simulations) reemployed elsewhere, albeit at lower

35. To understand technically how that can be done with MOSES, see **Eliasson (1980a)** where the Swedish tax and income transfer system, as represented in MOSES, is presented.

wages. That the speed of market correction so estimated is not that unrealistic witness the ex post assessment of the study in ***Carlsson et al., 2018***. When Government abandoned its previous employment protection policies, allowing the labor market in particular to conduct its allocation functions better from 1995, industrial structures promptly began to reorganize, and production growth shot up with statistically negligible adverse consequences for unemployment. The main cost to Swedish society was a lowering of the level of economic wellbeing (GNP/capita) that the economy had not been able to recoup by 1995, which was very much what model simulations had also demonstrated).

The publications summarized in Sections 1 and 2 above are studies on the *internal artificial realities* of the MOSES model economy, and what different market organizations generally mean for macro. When the MOSES model was used in the late 1970s to evaluate the economy wide costs and benefits of the ongoing industrial support program the Planning Survey based initial state had just been installed (for 1976) , but the couple of dozen parameters that regulated the long term sequential market feed backs on firms had at that time only been calibrated using the hands on manual procedure of ***Eliasson (1978a)***; ***Eliasson (1978b)***; ***Eliasson and Olavi (1978)*** (also see section 3.10). We were therefore reluctant to push the politically sensitive empirical results to hard, although in retrospect mistakenly so (see follow up study in ***Carlsson et al., 2018***). Only with the ***Taymaz (1991b)*** calibration program, and new specifications of the model we more confidently began to refer to results from MOSES studies as being valid for a Sweden like industrial economy.

In a number of studies Gerard Ballot and Erol Taymaz have taken the original, calibrated model as given, added new modules, recalibrated the model and, using the new computer-based calibration program ***Taymaz (1991b)***, and set MOSES up for empirical human capital based inquiries. I therefore place them among the empirical studies of this section.

4.4. Labor markets, worker training and macro

Technically, labor in MOSES is homogeneous, but depending on what machinery workers operate labour productivities vary widely across the firm population (see Salter curves in Figure 2 in ***Eliasson, 1991a*** and in ***Figure 1B*** in ***Eliasson and Taymaz, 2001***). This coupling of workers' productivities with the machine capital of the employer was an acceptable approximation when the MOSES project began, and before, but has become increasingly wrong with the advent of a New Economy with a large and growing share of human capital intensive service production that, depending on market circumstances, can be conducted within a hierarchy, or be out contracted in the market. In a series of publications Gerard Ballot and Erol Taymaz have improved upon MOSES specification of human capital input in productionin by introducing both general and specific training of workers, to make labor in practice heterogeneous. Even though individual workers could not yet be followed as they moved from firm to firm, the model kept track of the average human capital stock of the firm, and how it was affected by general and specific training of its workers, and how that stock changed when its trained workers moved to other firms (***Ballot and Taymaz, 1993***; ***Ballot and Taymaz, 1996***).

4.4.1. Labor hoarding

The macroeconomic consequences of different labor market organizations were an early concern in MOSES analysis. ***Eliasson (1977)*** used the richly specified labor market processes to study the economy wide consequences of a new labor hoarding law to protect workers from temporary layoffs. This was also the first MOSES study based on Planning Survey data, first installed in the 1976 initial state database. While the ambition primarily was to test the model for reasonable behavior, and to demonstrate what the MOSES model could do, it, however, told a story not entirely familiar and therefore worth documenting. First, this so called Åman law did not necessarily have any effect on employment. The costs for rehiring normally keep firms from laying off workers for short term reasons. Second, firms in the MOSES database, we later found by studying the panel data of the MOSES database (***Eliasson, 1992b***), normally hoard workers, but to a varying extent, to be able to flexibly adapt production to variations in demand. Third, when firms are forced to keep workers employed for up to a maximum of six months, which they would otherwise have laid off, model simulations predict that society incurs a double-sided transactions cost. The immediate effect is lower output. Since firms, however, also reorganize to maintain their profit margins the incidence on profits of the Åman law is almost entirely shifted back onto all workers of the firm in the form of lower real wage increases. All this comes in the form of endogenous adjustments within the firm model. So if the Åman law was instituted as an insurance against unemployment, it appeared (1) not to be effective, and (2) the costs of this not effective insurance was squarely carried by the worker collective, not by the firms, as was the original political ambition.

4.4.2. Firm sponsored training and growth

With labor heterogeneous it has been possible to simulate the macroeconomic outcomes both on firms' investments in human capital and of the consequent reallocations of that human capital over the labor market. Such labor market reallocation experiments also demonstrate the macroeconomic importance of *the labor market as an allocator of human competence capita*l. Workers at one firm can be trained by the firms which thereby upgrade their productivities when operating the machines of that firm, and thus also become attractive for poaching by competitor firms.

Becker (1964) had proposed that firms would not pay for *general* training because their workers would then all be raided by competitors. ***Ballot and Taymaz (1993)*** reject Becker' s proposition as partial and wrong, because it assumes the labor market to be in general competitive equilibrium. A firm investing in general training would therefore almost immediately lose the value it had created in its now better trained workers. Despite a general argument that human capital, and trained workers in particular, is critical both for individual labor market performance, and firms' competitiveness, little or no data , they observe, has been collected on firms' investment in training, notably general training. Ballot & Taymaz found (using the MOSES database) that firms in fact invest in general training, that a complementarity existed between investments in general training and R&D (necessary for R&D to contribute to innovations), and, interestingly, that investments (in general training) depend negatively on the quit rate, a relationship that should not exist under the partial ***Becker (1964)*** proposition. ***Ballot and Taymaz (1993)*** and ***Ballot and Taymaz, (1996)*** therefore concluded that firms in fact invest in general training, contrary to Becker's influential but wrongly conceived theoretical proposition, but also that they still *underinvest in general training because they cannot fully recoup training investments*.

Ballot (1994) points out that firms should often find it profitable to invest in general training to build the complementary human capital needed for R&D investments to create innovation rents. Since the training firm knows the quality of its trained workers better than the raiding firms do (asymmetric information) it should therefore, because of the innovation rent created by its generally trained workers, be able to pay more than raiding firms. ***Ballot and Taymaz (1996)*** follow up on this argument by adding a training and innovation module to the firms of the MOSES model (which never finds itself in competitive equilibrium), and confirm through simulations that generally trained workers will not all be raided because their general training, complemented by investments in R&D, earns the firm an innovation rent that allows it to pay sufficiently high wages to keep poachers away.

Ballot and Taymaz (1996) however also found, through MOSES simulations, that while the innovation rent is a necessary condition, it is not sufficient. To turn the technologically defined innovations created by investments in general human capital and R&D in combination into a monopoly rent that protects the firm from being poached by other firms by paying higher wages, *complementary specific training is needed to make the technical innovations raise the firm's earnings capacity, and more than the poacher can afford*. The MOSES model allows this complex story to be captured within one theoretical framework. Thus ***Ballot and Taymaz (1997)*** summarize their findings by concluding that *the optimal time sequence of firms to allocate their resources is first to (1) build the general human capital needed to complement (2) investments in R&D to make it productive in turning out technological innovation rents. Then (3), however, investments in specific training are needed to make good money on ("commercialize") the innovations*. Only then will the innovations be converted into the monopoly rents that raise earnings capacity and the ability to pay the higher wages necessary to keep poachers away (Cf competence bloc theory in section 2.1).

When ***Ballot and Taymaz (2000)*** expand on their 1997 simulation studies they find that because "general trainers" (as explained above) are technological leaders they generally fare better than poachers, that are imitators. Even though technological leaders will eventually fail to stay leaders this is sufficient to demonstrate through simulations that general trainers and poachers/imitators may coexist, even though the composition of the firm population is constantly changed through entry and exit (turnover) of firms. Consequently, not only does this market churning maintain the heterogeneity of production structures needed for the existence of viable markets that self- coordinate the economy. It is also a general prerequisite for growth to occur.

Ballot and Taymaz (1998) had introduced a human capital and technical innovation module based on genetic algorithms in the MOSES firm that now came in handily.[36] ***Ballot and Taymaz (1999)*** used that module to open up a new research field based on the above results on how the firm allocates their resources between human capital accumulation ("training") , investments in R&D and in physical capital, making use of the complex *internal artificial reality* of the MOSES model. Since that artificial reality had been built on observations on how firms interpret information known to be available, form anticipations and use rules (that can realistically be represented by mathematical algorithms) to make decisions, not least on whether to, and how to revise future plans and decisions on what they had learned from their expectational mistakes. Selection therefore becomes the typical feature of both internal decisions in MOSES firms and the sorting out of winners and losers in its markets (see Section 1). It thus becomes interesting not only to study the economy wide role of Stockholm School ex ante plans and ex post outcome feed backs at the agent level, but also how *firms learn to improve their decision rules from experimentation and experience,* and how such improvements affect economy wide performance.

Of particular interest was if improvements of rules, and of firm performance, through learning from experience would lead to *increased homogeneity in the firm population*, and which types of improvements that would help the economy to maintain or increase the heterogeneity of structures built into the initial empirical structures on which MOSES simulations started. This heterogeneity had been found to be critical for long term stability of market self-coordination of the MOSES model economy (***Eliasson, 1984***; ***Eliasson, 1991b***; ***Eliasson, 1991a***; ***Eliasson, 1991c***). To evaluate that, ***Ballot and Taymaz (1999)*** use the Holland type classifier system (already being part of the MOSES firm model since ***Ballot and Taymaz (1998)***. Each classifier system features three activity levels: performance, credit assignment (potential payoff), and discovery. Firms experiment in proportion to their stock of general human capital, which thus raises the probability of a positive pay - off from low probability high pay off radical R&D investments. Discovery refers to the genetic algorithms that generate, for instance mutations that make the firm act rather than not, or crossovers, in which it adapts another set of rules from its own memory or imitate a set of rules from another firm. This set of rules ("classifiers") are of the type, do nothing (0), act (1) or do not care (#). Each firm keeps a certain number of rules in its memory that are updated through additions and deletions by expernce, that decide which rule to apply to each condition. (For simplicity the number of rules in the memory is assumed to stay constant). Different conditions (such as a deterioration in profitability) require different rules of action. In the experiments five conditions are recognized and the firm can take four types of action on whether to invest in (1) R&D, in (2) general training, in (3) fixed assets, and (4) whether to change the planned output level. In principle, however, the numbers can be made arbitrarily large and/or be customized for firms.

These rule learning algorithms are applied in 50-year quarterly simulations with Stockholm School feedback of ex ante- ex post expectational outcomes. 20 Monte Carlo experiments are run around each varying the stochastic seed that determines which type of firm, drawn from an empirical distribution, that will enter that period, and in which order workers are informed about vacancies in other firms. *Ballot and Taymaz find that boundedly rational agents that learn from experience are capable of self-coordinating the MOSES economy by acting on their own often grossly mistaken expected profit prospects.* Rule learning, furthermore, gradually improves the allocation of resources, raises the technological level of the economy and increases long term growth.

Entrepreneurial entry is thus again found to be an important long run growth factor, and not only by upgrading the quality and diversity of production structures, but also by subjecting incumbents to competitive pressure, thus depriving low performers of resources, sometimes forcing them to

36. Firms use genetic algorithms, search algorithms that are based on the ideas of natural selection and genetics to discover better technologies. Search is random but success depends on the firm's general knowledge and luck in combining it with its specific knowledge, with other firms' knowledge, and whether it is only imitating, or chooses to "outreach" to experience high profit low probability mutation outcomes. In some experiments firms in precarious competitive situations have been modelled to opt for the latter high risk behaviour. The search algorithms used in MOSES are quite complex. See ***Carlsson et al., 1997*** republished in this Anthology. For for more details, see ***Ballot and Taymaz (1998)***.

exit, bu also compelling them to innovate premtively to prevent being forced out of business (See Schumpeterian Creative Destruction in ***Table 1***). Since investments in radical R&D, and in general training increase the rate of generation of radical innovations, and thus change the market conditions firms act on, the usefulness of existing rules constantly changes and raises the expected pay off from searching for better rules. ***Ballot and Taymaz (1999)*** thus *conclude that (1) rule learning by boundedly rational ("ignorant") agents improves economy wide (market) self-coordination, and (2) that (despite this learning) there is no tendency towards uniformity*. The healthy diversity of structures needed for markets to self-coordinate the economy (***Eliasson, 1984***; ***Eliasson, 1991b***; ***Eliasson, 1991a***; ***Eliasson, 1991c*** is thus endogenously maintained, entry being the factor that keeps market competition constantly turned on, as well as upgrades structural diversity through innovation (see Sect.2.3 above).

Finally, the initial complexity of the MOSES economy and the continued maintenance of a forever diversified population of agents /production structures by new technology creation, learning and endogenous rule change mean that one "cannot exclude that better designed decision rules" exists than those that have so far endogenously evolved through experimentation and learning (Op cit page 18).

4.4.3. Complementary human capital is needed for investments in R&D to be productive - the partiality syndrome

Policy recommendations based on partial models that lack market functions are high risk advice (***Eliasson, 2023a***). The relative importance of technology and economic factors in economic progress became a policy controversy in the 1970s among economic policy advisers about how to take industrial economies out of their post oil crises stagnation. ***Freeman (1974)*** had proposed a policy model based on a direct R&D investment (subsidized by Government) GNP drive. These, as they became called, "national innovation systems" models, sometimes referred to as the "linear ***Schumpeter (1942)***", were streamlined by ***Nelson (1992)***; ***Nelson (1993)*** and ***Lundvall (1992)*** and became popular among economists at engineering universities and even in the OECD, because they gave central government a well defined theoretical role to overcome the stagnation. This partial R&D fueled technology driven model however provided delusive policy advise in that it neglected the role of markets in commercializing new technologies, and echoed ***Solow's (1987)*** failure to understand both the complementarities between technology introductions and human capital in economic growth that ***Griliches (1969)*** had pointed to, and the role of markets in identifying, selecting and commercializing new technologies. Since the MOSES model internalized those market selections (Sect 3.2) we became actively critical to the increasingly popular national innovation systems policy propositions (***Eliasson, 2017b***).

Griliches' (1969) observation that there may be a complementarity between physical capital and human capital was also a kind rejection of the narrow Becker proposition that firms do not sponsor general training of workers (See Sect. 4.4.2 above). In approaching the question of how human capital and innovation generate macroeconomic growth ***Ballot and Taymaz (1997)*** called in the more general perspective of the MOSES model to integrate the two partial models within the firm model of the MOSES economy. By taking their analysis down to an explicit market allocation based microsimulation platform B&T could thus distinguish between the relative roles of human capital (or business competence), technical innovations to create new technologies (innovation), and the pickup, imitation and scale up (commercialization) of new technologies available in the market. By broadening the notion of specific skills to the concept of *receiver competence* (***Eliasson, 1990a***; ***Eliasson et al., 1986Eliasson, 1990b***) a new perspective on innovation, entrepreneurship, commercialization and economic evolution opened (see Section 2 on competence bloc theory) and in the end to generate macroeconomic growth.[37] In doing so, ***Ballot and Taymaz (1997)*** demonstrated that investments in (complementary) general training to create new technologies may be a waste of resources if the firm does not also have the *specific* skills, mentioned above, needed to convert the new technologies created into innovation rents by advancing productivities and earnings capacities (commercialization and scale up).

37. Cf the related concept of absorptive capacity of ***Cohen and Levinthal (1990)***.

Since generally trained workers are free to leave, ***Ballot and Taymaz (1997)*** had demonstrated, some raiding competitor firms will probably offer sufficiently high wages for some generally trained workers to leave. The firm therefore only invests up to a limit in training, because the employer knows the productivity of its own workers better than the raiding firm does, and therefore can afford to pay higher wages than most competitors are willing to offer. However, ***Ballot and Taymaz (2001)*** point out, because firms cannot fully recoup training costs, they tend to *underinvest in general training* compared to what would be socially profitable.

4.4.3.1. Innovation supply

As it seems, the bulk of R&D spending in manufacturing firms is devoted to "receiving" and commercializing new technologies developed elsewhere locally, and integrating them with their own technologies into a new combination, rather than creating entirely new technologies (***Eliasson, 1991c***). By also adding a new module of R&D based innovations generated by genetic selection mechanisms (partly explained in ***Carlsson et al. (1997)***, but fully in ***Ballot and Taymaz, (1998)*** and ***Ballot and Taymaz, (1999)***, B&T had integrated the two partial mechanisms and generated very different macro-outcomes than what each partial model would do, thus turning traditional results on their head. Turning off the commercialization process (that includes imitation) in the ***Carlsson et al. (1997)*** study almost eliminated the positive growth outcomes of technological innovations, and thus negated the large part of the "Schumpeterian inspired national innovation systems" studies, propositions that at least the young ***Schumpeter (1911)*** would not have subscribed to.

4.4.3.2. Receiver competence

The receiver competence concept is further expanded in ***Ballot et al. (2006)*** into a *competence bloc* of market actors with various specialized competences partially integrated in the MOSES model. It is demonstrated there how venture capitalists that learn from their investment experience contribute positively to macro-economic growth.

Eliasson (2017b) noted, with reference to these simulation results and the econometric results of ***Gunnarsson et al. (2004)*** that the ***Solow (1987)*** "productivity paradox" represented a typical partial miss understanding in that the missing productivity expansion, despite enormous IT investments in the US, depended on deficient supporting human capital. ***Ballot et al. (2006)*** had found that *training general skills* mostly *raised the capacity* of the firm to create new technologies by R&D or imitation, or a combination of the two. General training should thus *precede the training of specific skills* that affect production directly by raising receiver competence and the capacity to commercialize innovations. Complementary specific training to build receiver competence was however needed to identify and commercialize winning technologies

4.4.4. New growth theory and network externalities in MOSES

The major channel for technology diffusion is the market for workers with superior human capital. By raiding competitors for new technologies embodied in human capital the raiding firm taps into the collective body of talent of that market. The more of that talent available the more individual (raiding) firms benefit, raising both the collective body of talent through market diffusion, and aggregate productivity. The more firms train their workers (even at the risk of being raided) the larger the collective talent capital available for raiding ***Ballot and Taymaz (2001)*** note. Raiding is a labor market function. Enhanced training spurred by fear of competition to raise rates of innovation and/or imitation, thus also raises aggregate productivity and makes firms on average more competitive. The more labor market competition in MOSES the larger the networking externality that ***Lucas (1988)*** and ***Romer (1986)*** introduced as (hypothesized) positive correlations between a collective measure of general human capital, and all factors of production (positive externalities) in their macro production functions (see ***Eliasson, 1996*** and Section 4.2 above). ***Ballot and Taymaz (2000)*** however also **explain how** (!!!) *that same externality may arise through enhanced labor market raiding of firms for talent* that forces each firm to innovate by engaging in more general training, or risk being competed out of the market, and to innovate more to be able to counter raiding firms' wage offers. *This market-based explanation is principally different from how econometric results on new growth theory macro models (that regress total factor productivity growth on a measure of collective R&D capital) are interpreted.*

Since the interpretations are different, they also suggest different policies. (It is of additional interest to note that this explanation of the market origin of network "externalities" could in principle have been investigated already on the original 1976 version of the MOSES model, although at the time we did not understand that theoretical potential. *The fear of being raided explanation of innovation* and endogenous growth was expressed differently in ***Eliasson (1995)*** *as precautionary innovation spurred by fear of being competed out of the market.* Together these two mechanisms suggest *a market explanation of the network externalities* statistically measured in macro new growth theory models.

4.5. New firm formation

Network externalities explain firm formation in that hierarchical organization beats the market in organizing production effectively. Competence Bloc theory (in Sect. 2) defines a cluster of financial market intermediaries that together support the creation, identification and commercialization of winning technologies and explain that this can occur in a market with autonomous such intermediaries, or by the same intermediaries being internalized within a business hierarchy as management functions. Competence Bloc theory is therefore a perfect theoretical platform to explain firm formation, and explicitly introduces such firm formation in MOSES (***Eliasson, 2023b***).

The business firm in MOSES is a financially defined entity. Its outer boundaries are determined in financial markets as different components ("divisions", technologies) are acquired or spun off to reconfigure in new business entities. Since the dominant production capital in a firm is human based competence (*The Firm as a Competent Team*, ***Eliasson, 1990a***), that is traded in the "labor market" (previous section) the financial and labor markets together form a powerful vehicle for building synergies or business hierarchical organizations called firms (***Eliasson, 2021***).

Ballot et al. (2006), and ***Eliasson (2023b)***, address the problem of the floating boundaries of business agents operating in realistically modelled markets in which financially defined business hierarchies ("business agents") constantly break up and recombine or establish themselves as separate business entities. Competence bloc theory (see section 2) was formulated to explain that organizational dynamic. ***Ballot et al. (2006)*** explain, using a simple learning model, how financial intermediaries within a competence bloc may learn through investment experience to build the industrial competence needed to identify winning technological innovations, and support their commercialization and scale up to industrial levels. This venture into the markets for strategic acquisitions and divestments based on competence bloc theory offers promising future modelling experiments (***Eliasson and Eliasson, 2005***).

4.6. Trying out new financial tools – the CAPM

The MOSES model encapsulates the static general equilibrium model as a special case. The Capital asset pricing Model (CAPM) developed by ***Sharpe (1964)***, was derived from the general equilibrium model, that has nothing to say on an economy out of equilibrium, or how it may move from one equilibrium state to another. It therefore became interesting to study (through simulation analysis on MOSES) the reliability of the CAPM model as a predictor of asset prices in a model where such a market equilibrium did not exist, and the economy normally operated far away from anything close to a capital market equilibrium, the latter being a property MOSES philosophy equates with empirical relevance. Such a study became possible when a new capital market system was substituted for the industrial banking system of the original model in ***Eliasson (2001)*** and ***Eliasson and Taymaz (2001)***. ***Broström (2003)*** also demonstrated through simulation experiments on that general version that CAPM predictions were generally unreliable, and the more so the more out of "capital market clearing equilibrium" the MOSES model economy.

5. Complex modelling as cognitive support for customized empirical analysis

There is *no universal economic model* that explains everything. The MOSES model does not claim to be universal, but it is much more general than most econometric models in that it integrates at least six familiar partial economic models associated with Keynes (macro demand), Leontief (input output, general equilibrium), Marshall (industrial districts, micro), Schumpeter (entrepreneurial entry), Simon (bounded rationality of agents, including Government), and most importantly Stockholm School economics (ex ante anticipations, and period to period feedbacks of ex post outcomes). These partial models are frequently used in isolation for policy advice. Stockholm School ex ante ex post feed backs of anticipatory mistakes of heterogeneous agents, furthermore, are a necessary condition for markets to at all exist and be capable of economy wide self-coordination. The fact that agents are boundedly rational is a consequence of the complexity of the economy wide self-coordinated market machinery of the MOSES model. When integrated, the Stockholm School factor merged with Schumpeterian entrepreneurial entry finally make dynamic markets come to life across the agent population (competition). Over time feed backs of agents' anticipatory outcomes (learning from economic mistakes) force agents to innovate preemptively, make markets self-organize the economy, and govern the allocation of resources across the industrial districts . When integrated into what I call an Experimentally Organized Economy (EOE) a very different animal confronts the economic analyst than offered by any of the six partial theories in isolation. Above all, *this integration was necessary to give markets and agents an autonomous role to play in economic systems analysis*.

Since all models, however complex, are still necessarily partial and therefore miss specified in many, often important ways, ***Feldstein (1982)*** suggested that frugal and simplistic models are OK, but that their interpretation requires a lot of experienced based knowledge and common sense. That is also OK. Economic advice and decision making therefore necessarily become an imprecise and slippery business. *You must have faith in the economic adviser to take him seriously*.

All good economic model applications are thus also necessarily customized for specified decision problems, and hence partial and wrong in many other contexts. *Serious economic analysis therefore always must be preceded by a careful choice of prior specification, into an appropriately customized model*. Macro models, for instance, have been construed to support policy making, notably demand policies, and may be wrong even in those applications because they suppress, we have found, the complicating roles of markets (***Eliasson and Taymaz, 1992***; ***Eliasson, 2023b***). Walrasian static equilibrium modelling, who knows what that is good for?

5.1. Interpreting macro in terms of the artificial internal economy of the MOSES model

The rich specification of the *artificial internal economy* of the MOSES model can now be used in a new role as *cognitive support in the choice of best partial model* to study a particular decision problem, or to interpret the econometric results from an obviously miss specified partial model that can be derived as a special case of a MOSES type model. These applications are greatly facilitated by the modular design of the model. Since boundedly rational policy makers bulk so large in the economy they exercise a heavy leverage on the entire economy, not least when it comes to the biasing of price signals in markets caused by tax and income transfer wedges. More important are the potentially large consequences of policy mistakes due to lack of understanding of the economy wide consequences caused by their interventions. Economic modelers in their advisory business must therefore take model design and verification seriously, and the prior customization of the model's specification in particular (***Eliasson and Taymaz, 1992***). MOSES thus also offers a way to add scientific precision to the final interpretation of econometric results that Feldstein's advice lacked. *Within its range of applicability the MOSES model therefore offers the possibility to derive useful partial models for econometric analysis that can be broadly interpreted with reference to the complete MOSES model system*. Are you facing a situation of insufficient Keynesian demand? Does the economy lack the Schumpeterian entrepreneurs that maintain the diversity of structures needed for stable economic growth, or is market competition distorted by Government regulation such that market failures are in fact policy failures? *Thus, MOSES allows the economic analyst to evaluate the social costs of being wrong in the choice of model, and hence of understanding.*

The MOSES model has other advantages too. It not only takes the specification down to the agent level, uses empirically recognizable categories and emulates documented decision processes based on (statistical) information from ***Eliasson (1976a)*** to be used by firm management, and collected in the Planning Survey of the Federation of Swedish Industries, which was specially designed to set MOSES up empirically. Since the MOSES model is dynamically self-coordinated by market agents with (autonomous) price setting capacities, policy interventions can be expected to conflict with the agendas of agents (***Eliasson and Taymaz, 1992***) and thus interfere with this self-coordination.

The modular design of the core micro market selection based endogenous growth machinery of the MOSES model has remained the same since ***Eliasson, 1976b*** and ***Eliasson, (1976a)***. Its calibrated parameters have also remained reasonably stable over the decades of MOSES development (Section 3.9 above). In so far as any of the partial sub models of the MOSES model is taken seriously as an empirical representation of reality, any policy maker needing serious advice, therefore, should be more than happy to transfer his/her attention to the MOSES model.

I will therefore conclude this section with reporting on some of these odd cognitive applications of the MOSES model in the borderland between theoretical and empirical analysis.

5.2. MOSES in Moscow – from plan to market

It began already in the late 1970s when my department at the Federation of Swedish Industries got involved in an academic exchange of researchers with the then Soviet Union, notably the Central Economic and Mathematical Institute (CEMI) in Moscow. At the time the centrally planned Soviet economy was creaking in its joints. The CEMI had been charged with studying ways to introduce markets in the rigid Soviet economy and some visiting Soviet economists got wind of the MOSES modelling project, among them Nicolai Petrakov, one of the directors of CEMI. It was agreed that a compacted version of MOSES be transferred to a Norsk Data desk computer at CEMI to be loaded with Soviet data. I, then director of IUI, and Bo Carlsson, my deputy director, helped CEMI researchers in the 1980s to practice the transfer of a centrally planned system to a market economy on the MOSES model. The idea was good, but at the time MOSES was not ready for such advanced studies, and the compacted Soviet version of MOSES had very little left of the complex market dynamics in ***Eliasson (1976b)***.

5.3. Central planning vs free market entry

Some academic papers on those MOSES applications on Soviet problems were however published by Soviet economists, but they were primarily devoted to presentations of the model to Soviet economists, and to identifying how a market economy distinguished itself (favorably) from a centrally planned economy, or for that reason also from the softer "dirigiste versions" practiced in France and Japan. Rather than how, we identified what not to do, and why static equilibrium modelling, needing the Walrasian central auctioneer to coordinate the economy, was a bad idea. ***Antonov and Trofimov (1993)*** demonstrated that mandating the firms in the MOSES model economy to follow Keynesian or Neoclassical macro model forecasts (reestimated every quarter on data generated by MOSES by the central planning authority) was a growth depressant. When freed of those mandates, the model economy outperformed the policy mandated version in generating very long run macro economic growth. When firms were left alone to use its own adaptive price anticipations and ad hoc decision rules, in the free market regime so defined individual firms happened to come upon, identify and commercialize winning technologies that they had missed under the constrained policy regime (Type II economic mistakes). (On the other hand, the GNP composition of output under the positive market scenario was endogenously determined and also beyond central policy control. In later MOSES studies we found that if global prices were developing close to a steady relative price change, and therefore predictable in expectation by firms' adaptive expectations algorithms, a central policy aimed at technological imitation, rather than innovation, might be a medium term winner, however leading to a technological lock in into old structures and a dangerous competitive exposure to unexpected global technological innovation of the Internet revolution kind). In ***Eliasson (1998)***, finally the results of MOSES simulations were incorporated in summarizing the benefits of a free market economy, but also the problems of achieving an orderly transfer of a planned economy to a market economy. That, however, in turn required, it was observed, that the institutions supporting trade in intangible assets, notably property rights, be developed (***Eliasson and Wihlborg, 2003***). The property rights institution was one of the pillars of a market economy in serious disrepair in the Soviet economy.

5.4. The Lindbeck commission

*I*n the early 1990s the Swedish economy found itself in a combined structural and financial crisis with stagnating production and severely reduced structural diversity. The Government asked Assar Lindbeck, a well known Swedish economist, to lead a Commission to suggest policy remedies. Special studies were subcontracted to economists across the country. I was asked to contribute something on micro to macro, a bit of Schumpeterian entrepreneurship and some results from our simulation studies on the role of human capital in economic growth (***Eliasson, 1993***). The Lindbeck commission came up with 113 detailed recommendations (*Nya villkor för ekonomi och politik*. Ekonomikommissionens förslag, ***SOU, 1993***). It, however, failed to take the micro to macro dimension explicitly into account, and the deteriorating diversity of production structures that we pointed to appeared not to have been taken seriously. Most (not all) of the 113 explicit pieces of advice, however, would anyhow have come out of a MOSES based study. We therefore published our own IUI analysis of the economic situation in ***Andersson et al. (1993)*** in which the need for a market directed reorganization of production structures was argued to be needed to restore a precariously deteriorated diversity because of a long-term decline in entrepreneurial entry. This, again illustrates the ***Feldstein (1982)*** remark that *all models are exactly wrong in some respects, but that they may still be used together with experience and common sense to come out vaguely right*. It also illustrated the method discussed in Section 5.1 to use the MOSES economy wide and general framework as cognitive support for partial analysis. It would thus not have hurt the case to test at least some of the 113 policy propositions of the Lindbeck Commission on the MOSES model for the possibility of being wrong, or simply irrelevant in the wider perspective of a complex economic situation. It was there, ready to be used.[38]

5.5. Why agent based models so far have failed to make it in macro economic analysis

In his 2017 article ***Richiardi (2017)*** asks why agent-based modelling and microsimulation methods have experienced such difficulties of becoming a standard approach to macro economics. About these models Richiardi observes that; (1) ad hoc and not well grounded assumptions are often resorted to, (2) too many degrees of freedom mean models are non-falsifiable, (3) lack of empirical grounding and ad hoc calibration mean lack of empirical credibility, (4) poorly documented specification prevents replication of experiments, and (5) great demands on technical and programming skills make both the use, and expansion of agent based models difficult. They tend to exist for a while in isolation and then be forgotten. We have been aware of these problems throughout MOSES' 50-year history, and they apply to almost all microsimulation models I know of, but this Anthology should show that they don't apply to the MOSES project. This Anthology should rather make clear about 1,2 and 3 that there is little or no ad hoc economics associated with the MOSES project, and that we have taken validation of the model seriously, perhaps even too seriously. In fact (4) was easily overcome in ***Broström (2003)***, a master student at Linköping Technical University who set MOSES up for advanced simulation experiments and concluded his thesis in six months. Also (5) should not be that much of a problem. My 17 year old grandson managed to convert MOSES to object oriented code directly from the coding manual and without doing it by way of the current APL code, to run a few experiments, and to write ***Lindstenz (2023)*** in three weeks (***Eliasson, 1976b***[39] That the Planning Survey includes critical proprietary data is a problem that was overcome with the creation of a deidentified version for external users by ***Taymaz (1992a)***. To set MOSES up for serious empirical work on a different economy than the Swedish one of course requires a separate Planning Survey to establish an initial state for that economy. Some more fundamental obstacles must however be at work on preventing economists at large from taking advantage of the great potential of the microsimulation method.

There must also be something wrong with a profession that has not taken advantage of the potential of agent based economy wide modeling, its opportunities for relevant empirical applications and for using simulation mathematics for general economic theorizing, and it is interesting to ask why. Thus, the introductory two sections on general analysis of the artificial reality of the MOSES model of an experimentally organized economy.

38. My institute, the IUI, in fact conducted a parallel economy wide analysis (***Andersson et al.1993***), in which the MOSES model was used, and we came out with roughly the same principal conclusions as the Lindbeck Commission.

39. That is the original 1976 version without the tax and income transfer system of ***Eliasson (1980b)***, and the sophisticated capital market regime introduced with ***Eliasson (2001)*** and ***Eliasson and Taymaz (2001)***.

6. MOSES validation and plans for the future

A modelling project that has reached the age of fifty (2024) must have a generational transfer problem. The three current active modelers are retired, and more interested in studying the artificial realities of the MOSES model economy when customized for different problems, than to engage in a new full scale empirical inquiry. But one experience acquired from the MOSES project is that even general theoretical analysis, to be interesting, requires relevant empirical specification. Current MOSES maintenance is therefore focused on conducting general analyses on the specification, database availability and calibrated parameters that we already have, and make sure to document what we have done so that somebody can take over the transfer job, and improve upon the specification such that MOSES can be quickly updated and readied for a full scale empirical project when a sufficient budget is offered. A must is then that the long-planned extension with a micro specified household sector be done to make possible empirically credible studies of how income and wealth distributions relate to economy wide progress. To be properly done the latter requires that the co-evolution of human capital and physical capital resource reallocations with asset prices be simultaneously studied. For that MOSES has to be translated from APL to object code such that that the flows of human capital between housweholds/individuals and production agents are made explicit. Parts of the needed data and model respecification for that was in fact prepared long ago. (see below). And the needed conversion of the model to C++ should not be that difficult. So doing interesting general micro to macro dynamics on the artificial realities of the MOSES model economy, and preparing it for future serious empirical studies on the basis of what we have already done, is the current strategy.

6.1. Empirically relevant design

I have made a point of the generality of the master versions of the MOSES model as they integrate a number of familiar partial models (Section 1.1), and the possibility to minimize the partiality problem by customizing the MOSES model from this master platform for particular applications (See section 3). Even so, technological and organizational changes in an advanced industrial economy like the Swedish one progresses at a rate that will leave the academic modeler constantly behind. And so do also the concerns of politicians wanting to change the composition of economic growth and the distribution of the benefits of economic progress. In order not to do worse they need the support of models capable of reliable advice on such matters. On this I have had the advantage of being for many years the head of a research institute (the IUI) that was constantly engaged in applied industrial economics research, and also been personally involved in down to the factory floor research (see ***Eliasson, 1976a***; ***Eliasson, 1980b***; ***Eliasson, 2013***; ***Eliasson, 2017b***). The MOSES specification was up to date on the structure of the Swedish economy during the early Post WWII period. Since then the real Swedish economy has been subjected to a number of fundamental structural changes, some of them being endogenously generated in the model, some attended to by a revised specification, and others only prepared for.

6.2. Needed and prepared for expansions of the model

The most needed modifications of MOSES are:

1. *Households* are still represented in macro, as in a conventional eleven sector Leontief - Keynesian model. Converting the household sector onto a micro foundation has been prepared for empirically with the HUS project managed by Anders Klevmarken in cooperation with IUI (***Eliasson, 1982***; ***Eliasson, 1985***; ***Eliasson and Klevmarken, 1981***). A micro household empirical implementation can thus be naturally integrated with the 1982 database. It should also be noted that a satisfactory micro household implementation for the most interesting applications (for instance income and wealth distribution consequences of more or less successful growth scenarios) does not need a database of thousands of households, which should therefore not be attempted. A sample of households of different human capital characteristics should be sufficient. The most challenging task when it comes to individuals will be how to represent human capital relevantly, not least how human capital, the dominan production capital appears in the formation and operation of firms (***Eliasson, 1990a***; ***Eliasson, 1990b***; ***Eliasson, 2023b***). Micro specification of households should therefore make a more realistic representation of workers' heterogeneous production capacities possible (see below and Section 4.4.2 above). The micro household extension of MOSES has however been held back by our early choice of APL as a

computer language. As we have learned a transfer to object code, then not developed, has long been needed. ***Derviz (1992)*** prepared a conversion of MOSES to object code, but we have so far not found a budget to do that full scale, except that ***Lindstenz (2023)*** has converted the early ***Eliasson (1976b)*** MOSES version to object code and managed to get this version up and running.

2. An extension of great principal interest would be to *establish a micro based intersection (market) between manufacturing firms and households*. That extension is needed to explain the role of human capital in the creation and commercialization of new technologies , and its compensation in the form of capital gains through the spontaneous formation of new business entities , and how differences in market regimes have governed this most powerful income and wealth distribution widening process in recent decades. Steps in that direction have already been taken in that ***Ballot et al. (2006)***, republished in this Anthology, model how specialized knowledge intensive commercializing agents detach and merge spontaneously from manufacturing firms and households to attract financial resources and support macro progress. ***Ballot et al. (2006)*** limit MOSES simulations to the role of venture capital firms that learn from experience and eventually, if in sufficient numbers, and with the needed experience, influence the macro economy. The long time it takes for emerging macro consequences of such spontaneous agent formation to show was a particularly interesting result. The extension of the model to cover such spontaneous formation of specialized commercialization agents within *competence blocs* (Section 2.1) should be possible with the realization of §1.
3. The §2 extension is a special case of the outsourcing of specialized production and services, even critical technological and commercial ones, that has fundamentally reorganized the industrial landscape during the last two or three decades in advanced industrial economies, much of it being moved by the digitalization of the economy (***Eliasson, 1996b***; ***Eliasson, 2013***). This in turn calls attention to the concept of the firm as a dynamic and internally constantly changing financially defined entity with unstable and endogenously changing intersections with its market environment. To stay relevant agent based economy wide modelling simply has to attend to this institutional dynamic and ***Eliasson (2023b)*** outlines a dynamic version of Coase's theory of the firm, suitable for modifying the current financially defined MOSES firm in this direction.
4. *Human capital is the dominant production capital* of the advanced industrial economy. It is largely tacit and cannot be meaningfully represented, neither as the measured capital stock of neoclassical production theory, something business firms have understood all the time, nor as a top-down managed hierarchy. Tacit human competences are decentrally allocated within hierarchies and over markets for competence, sometimes called labor markets, to form competent teams, called firms (see ***Eliasson, 1990aEliasson, 1990b***). The great challenge would be to model the creation of new tacit knowledge and its endogenous agglomeration in markets into firms or competent teams . A revised firm model in MOSES that captures this has long been prepared (see ***Eliasson, 2021***; ***Eliasson, 2023a***; ***Eliasson, 2023b***, and could naturally be integrated with the work on labor markets and human capital accumulation in the MOSES model of Ballot & Taymaz (see Section 4.4).
5. Introducing human capital explicitly in MOSES however raises the difficult problem of modelling quality. To some extent Gerard Ballot and Erol Taymaz has already made human capital heterogeneous in MOSES (see Section 4.4.2), but a micro household sector (§1) would be a great step forward in that respect. §4 above is about how markets evaluate human capital in production decisions. More problematic will be to represent quality differentiation in product markets, especially since new technology creation over MOSES history has shifted from allocating R&D investments to the raising of manufacturing productivity towards increasing product qualities. The assumption that markets perfectly represent product quality change in prices was reasonable before the new Millenium, but is no longer. With households being modelled in micro, not only labor can be made heterogenous, but also the possibility of modelling customer competence in appreciating product quality in their purchasing decisions.
6. As I have suggested several times, the MOSES model is an excellent platform for formulating *a general, market based theory of industrial economics*, as distinct from the static industrial organization (IO) models that lack general markets that connect agents to macro (***Ballot et al., 2015***). Microsimulation methodology is the appropriate tool to advance such new theory formulation. On this I agree with ***Richiardi et al. (2024)*** that micro simulation and agent based modelling are just versions of the same thing, and that the two ought to have fruitfully converged long ago. Tunnel perspectives on both sides have prevented learning from one another.
7. An interesting study of the kind I am advocating would be to address the ergodicity characteristics of dynamic economy wide modeling, that ***Samuelson (1968)*** argued are fundamental to good

economic modeling, in the context of the transactions costs intensive market self-coordination of the MOSES model economy. Ergodicity is a special case of self-coordination, namely when markets guide the economy to the same final state, irrespective of initial conditions. Since the models Samuelson was referring to have no markets, my proposition is theoretically different. A wider definition of ergodicity, applicable to the MOSES model economy would therefore be to study under what market circumstances the MOSES economy stays bounded from above and below under a market self-coordinated regime, and to investigate what happens when that wide band within which the economy evolves is gradually narrowed by policy intervention to, for instance, make markets more efficient, or to remove cyclical unemployment spells (for such countercyclical policy experiments on MOSES (see ***Eliasson and Taymaz, 1992*** in this Anthology). The more narrowly bounded the closer to the mathematical definition of an ergodic model it would come. I have argued that an interesting policy experiment would be to try to" policy manage" the MOSES model economy into a reasonably narrow bounded such range that expands as rapidly as is possible without becoming unstable over the longer run. Trying to pin the MOSES model economy down on a steady state, and the same steady state irrespective of initial conditions, the ultimate definition of an ergodic process, we already know will be a vain ambition, since such a state is not an attainable state in the MOSES economy. However, trying to identify a maximum possible welfare compatible such expansion range through policy simulation would be an interesting policy study (see section 1.3).

The MOSES economy is of course not free of external constraints. Its self-coordination property for most of its life has occurred under an upper exogenous global technological boundary, a constraint that was partially lifted with the ***Ballot and Taymaz (1998)*** firm based endogenous innovation module. Exogenous foreign prices, including the foreign interest rate still constrain market self-coordination, even though there is no lower boundary, since the model economy might collapse completely if development reduces its diversity of structures too much. For instance, markets in MOSES stop functioning when the number of firms has been reduced below three. They stop functioning well already when agents become too similar (too "representative", ***Eliasson, 1984***; ***Eliasson, 1991b***; ***Eliasson, 1991a***; ***Eliasson, 1991c***), and there is no Walrasian central price setter in MOSES capable of taking over the market coordination job. A study of fundamental theoretical interest would therefore be (see Section 3.4) to explore the market self-coordination, and thus "ergodic", properties of the MOSES economy further by endogenizing also global price determination and the interest rate. The ***Ballot and Taymaz (2012)*** cloning of MOSES models into a global economy has already laid the foundation for such a study. By adding trade in innovations (technologies) between the cloned MOSES economies, the global pool of best practice technologies could also be endogenized, and foreign prices be endogenously set by trade between the cloned economies. Such experiments on the MOSES model economy would take us closer to understanding the dynamics of an Experimentally Organized Economy.

To be remembered is that none of the above suggested expansions of the MOSES model will need full scale empirically implemented and recalibrated versions. The fact that the MOSES project has been prepared for a full scale empirical implementation that has not yet been achieved has a historical explanation. Something such ambitious was a prerequisite to get the project started in late 1974, and it is still within a realistic horizon. The generalization work sketched above can however take place more modestly and independently of realizing the full-scale empirical ambition, and on the basis of what has already been done. But the theoretical ("academic") studies on MOSES that we currently focus on will make the model better prepared for future empirical projects, and with time such a full scale empirical inquiry will be necessary to build a new structurally upgraded empirical master platform for future theoretical analyses.

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Conflict of Interest

No competing interests reported.

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Appendix A

A.1. Moses design, data base and calibration chronicle - master versions

The MOSES model was designed from the outset to be an empirical model, and this Appendix briefly documents the data requirements for setting the model up for empirical applications. Over the years the model has however been used increasingly as a theoretical design for general economic analyses, which are less demanding on empirical verification.

The point made by the selection of papers in the Anthology, and in this Introduction, is that micro simulation or agent-based models of MOSES type offer a broader economic understanding than do models squeezed into the standard mathematical framework of economics. Numerical simulation mathematics has opened a vista of empirically relevant general economic theorizing that largely remains unexploited. During the last couple of decades MOSES research has moved in that direction. An economy wide, agent based, nonlinear and initial state model to be economically interesting, however, requires a minimum of empirical input that characterizes the economy being studied. The most important empirical characterization is embodied in the model's specification, which should therefore be empirically well grounded. It is, for instance, hard to imagine dynamic economics to be interestingly pursued without behaving agents, market selection and periodic feed backs, and thus non linearities and initial state dependencies. Much of the empirical characterization is therefore also defined by the initial state, which is needed to start a simulation experiment, the latter being a matter of good economic measurement. This foundation of MOSES modelling is different from other models aspiring to be general. It is mainly due to its micro market foundation and unique Stockholm School expectations ex ante ex post learning, and feedback loops at agent level, the latter being very familiar features of real business life. In the end I therefore plan to develop a general theory of industrial economics based on the MOSES design, that will be distinctly different from static industrial organization (I/O) theory (see Section 6). This Appendix therefore illustrates how alternating theoretical and empirical studies on the MOSES model has made it increasingly more relevant for pursuing such ambitions.

A.1.1. General

The MOSES model consists of a system of equations F(..) that transforms vectors of initial endogenous variables y(t-1) , of exogenous variables x , and of parameters (ϴ) into a vector of future endogenous variables y(t), with a composition that is identical to the initial vector the period (quarter) before.

It is sometimes considered desirable that an economic model F(..) be "robust" in the sense that endogenous variables are independent of initial conditions such that a minimum of data is required , that y(t) = F(..) becomes universally true and that the past history of y is embodied in F(..) and its parameters. On this ***Binmore (1995)*** observes ironically that there are economists who consider initial state independent models superior to other models "because they are able to generate predictions with less data". Not so with MOSES. The MOSES model is very data demanding by design. Its specification is however such that direct measurement of its initial state y(t-1) has eliminated several parameters that would otherwise have been needed to explain how the model economy arrived at y(t-1). In explaining y(t) = F(y(t-1), x) a large part of the effort therefore goes into determining (measuring) y(t-1) which operates on y(t) in the same way as the exogenous variables. Direct measurement of the initial state thus substitutes for parameter estimation.[1]

1. Thus measurement errors in the initial state data base "substitute" for errors in parameter estimation. To evaluate the sensitivity of MOSES predictions to those errors, ***Taymaz (1992b)*** has fed random noise into a series of long run MOSES simulations, and found that with, and without, noise Salter distributions

A.1.2. Exogenous variables

To run the model, a statistical representation of its initial state, numerically determined time reaction parameters and a vector of exogenous variables, as long into the future as the model is to be simulated, are needed. The exogenous variables relate the MOSES model to the outer world. They are (1) productivities of best practice globally available technologies brought into individual firms through their endogenous investments, (2) global prices on each micro modeled market in the model, (3) the global interest rate, and (4) the labor force.[2] *The MOSES model thus operates under an exogenous upper global technology bound*. It is important for long run simulations that these exogenous variables be long run internally consistent (see Sect.3.4). Section 6 outlines a theoretical extension of the MOSES model that would endogenize a consistent global price determination for theoretical "academic" applications.

A.1.3. Measuring the initial state

Being a selection based nonlinear model MOSES is *initial state (history) dependent*. In fact, market selection and its Stockholm school period to period sequential feedback dynamics mean that observed search algorithms in many places form short period (quarterly) recursive schemes that substitute for traditional reaction coefficients, distributed lags, or stochastic equations, and thus reduce the number of parameters needed to be estimated (Section 3.9). Compiling a high-quality micro to macro and stock flow consistent initial state is therefore important for any claim to have carried out an empirical study (Section 3.11).

The initial state is no equilibrium state as economists understand that term. Neither is it a "temporary equilibrium". On the contrary, each initial state is populated by production agents, all being constantly exposed to threats to be competed out of business, and therefore constantly on their way to secure better and safer, but unattainable states for themselves. The initial state therefore becomes a "snapshot" picture of a market *equilibrating process* that normally stays bounded from above and below , but that may topple over if seriously disturbed, Wicksellian cumulative inflation being one example (***Eliasson, 2017a***), near economic systems collapse another (***Eliasson, 1991b***). Equilibrium resting places thus don't exist in MOSES (Section 2.3). A simulation furthermore generates consistent micro to macro-SF consistent states from quarter to quarter, and under "ideal" market circumstances, forever . Hence it is of general economic interest to ask whether the MOSES model exhibits "ergodic properties" in the sense that it tends to converge into the same approximate state in the very long run, irrespective of initial conditions (see again section 2.3). However, I do not regard this to be a necessary property of an empirically relevant economic model, and MOSES simulations for as long as we have simulated them tend to diverge significantly (***Eliasson and Taymaz, 2000***). On the other hand, in the more practical context of this Appendix it is important to note that exogenous variables and parameters can be manipulated to generate a synthetic future state with desired properties to start a particular study from.[3]

A.1.4. Testing MOSES for desired long run empirical properties

Over the longer run we therefore demand that the model economy stays viable under "normal" circumstances. In early experiments the model became collapse prone when the diversity of (endogenous) production structures had been reduced too much (***Eliasson, 1984***;

of firm performance variables do not differ appreciably. He concluded that random measurement errors in initial state variables should not be much of a problem even in medium term simulations.

2. This is a demographic variable. Labor supply and labour market participation is endogenous. For instance, employed workers leave their jobs if wage offers from other firms are above their reservation wage.

3. Empirical studies based on equilibrium models (eg computable general equilibrium models) have a different problem of the same kind. To run, for instance, a cost benefit study they need to start from one equilibrium and be moved to another, but the data the modelers have are cyclically biased, They therefore need to correct the initial database for cyclical factors using ad hoc methods. MOSES can be naturally moved onto such an initial SF consistent "balanced" state by its own markets through simulating the model there, varying exogenous variables.

Eliasson, 1991b; ***Eliasson, 1991a***; ***Eliasson, 1991c***). That undesired property disappeared when sustained diversity had been restored through the introduction of new innovative (also endogenous) entry (***Hansen and Heckman, 1996***; ***Hanson, 1986***; ***Taymaz, 1991b***). A related example is that markets in the model stop functioning when the number of firms has been reduced too much by excessive exits. This should not happen under normal circumstances but can be engineered by subjecting the markets of the model economy to extreme exogenous pressure, for instance extreme policies , or other external shocks (see ***Eliasson, 1978a***; ***Eliasson, 1978b***; ***Eliasson and Taymaz, 1992***). It can also occur if firms are excessively myopic, and for that reason make the economy generally vulnerable to external disturbances. The latter occurred when MOSES firms were subjected to the oil price shocks that hit the global economy in 1973/75 and started the next period with excessive inflationary expectations ("price overshooting") that led to an extreme wage escalation. When wages got stuck at the high levels, but product prices dropped back, notably in in raw materials and intermediate product markets, a macro economic disaster occurred both in the MOSES model and in Swedish reality (See Section 4.3). Real firms may in fact use naïve expectations algorithms (see ***Eliasson, 1976a***), which may lead to such consequences when markets get disturbed. To that end we complemented the first myopic smoothing expectations algorithms with both an error correction (learning) and a risk aversion component. This memory of past expectational mistakes was introduced in the early expectations functions of firms after we had compared the rates of diffusion of exogenous price shocks in the MOSES economy with the rates of price transmission that occurred after the oil price shocks in the Swedish economy (***Eliasson, 1974***; ***Eliasson, 1976b***; ***Eliasson, 1978a***; ***Genberg 1974***; ***Genberg, 1983***). The general picture that emerged was that price transmission througha diversified economy takes time andif excessive to begin with is likely to be boosted ("price overshooting") and prolonged. Compiling a high quality micro to macro and stock flow consistent initial state description that also includes a past history of individual firms' market experiences is therefore a requisite for having carried out an empirical study on the MOSES model (Section 3.11).

A.1.5. Scale up to NA level, the creation of synthetic firms and getting distributional characteristics right

The empirical ambition included scaling the MOSES model up to Swedish National Accounts (NA) level such that all stock and flow data in the initial state and then generated had magnitudes comparable to official NA data (***Eliasson, 1976b***). Manufacturing sectors in the NA accounts and the input output table were thus reorganized according to the market taxonomy used in the Planning Survey (***Albrecht, 1978***; ***Albrecht, 1979***). For each manufacturing market Planning Survery firms were then aggregated and the difference to the NA accounts so obtained, one residual firm for each markets, computed. Each residual firm was then divided up into component firms such that known distributional patterns (sizes, productivities, wages etc) to the extent possible were maintained. The problem was that inconsistencies between the different databases, and statistical errors tended to concentrate in the residual firms . This meant that among the synthetic firms so obtained some had been created so handicapped as to be incapable of surviving the competition in MOSES markets. During the first couple of years the MOSES economy was therefore shaken by massive firm death (exits), then to emerge with a new micro to macro stock flow consistent initial state, the distributional characteristics of which we could then compare with a new Planning Survey two or three years later. In most simulation studies we thus allowed for a two or three year break in period. For principal ("theoretical") studies this was not a problem. Testing for the accuracy of the new initial state so obtained would however have to await new final NA accounts data to arrive, and even so it was an open question whether the MOSES generated NA data or the official nationall accounts were the most accurate ones. Since MOSES can generate consistent quarterly micro to macro stock flow National Accounts data of creat detail, we have even considered using a calibrated MOSES model to generate the statistical NA accounts that do no yet exist for the Swedish economy. Ponder then that the market based aggregation achieved in MOSES simulations in many ways reproduces more consistently what is currently done manually in the Swedish Central Bureau of Statistics.

A.1.6. Calibration

During the first years of MOSES life demands on computer capacity were large. IBMs largest computer system in Europe could accommodate a five year simulation of some 90 firms by quarter. IBM, however, eased my concerns about this, and promised that this problem would soon be overcome. Computing costs, nevertheless remained a serious problem after IBM left the project in 1977, and until Erol Taymaz had transferred MOSES to a PC in 1987. Until then our possibilities to validate the model through multidimensional calibrations, sensitivity analyses and long run tests for undesired systems properties, remained limited.

Estimating the parameter vector Θ, however, poses special problems because of the model's selection features, nonlinearities and initial state dependencies. Following ***Hansen and Heckman (1996)*** we prefer to refer to what we have done as *calibration*, until a satisfactory method to determine the stochastic properties of the calculated parameters has been worked out. This is a technical notation and does not mean a downgrading of the empirical credibility of our results. Estimation difficulties depend on the model specification, the empirical credibility of which, in my view takes priority in determining the empirical credibility of the entire model (see Section 3.5). The thoroughly researched and robust design of the MOSES model has also meant that direct measurement in many places substitutes for parameter estimation, that has in turn considerably reduced the number of dynamically critical parameters that would otherwise have had to be estimated.[4] Thus, for instance, by substituting directly observed (in ***Eliasson, 1976a***) expectations and decision algorithms in firms for time reaction equations the number of parameters that regulate the economy *wide dynamics of the model has been reduced to a couple of dozens. In early versions of MOSES, for instance, firms exited when they had run out of* equity. Laid off workers were then supplied in the labor market, depreciated machinery was supplied in the investment goods markets, and the firm's product inventories were added to market supply. In later versions of the model a more realistic option for firm management to shut down before all equity value was gone was added.[5] These decision sequences are repeated as period to period (quarter) feed backs, that give the model a nice "recursive" short period structure and reduces the need to estimate artificial lag equations. The remaining parameters have been calibrated to fit as closely as possible to an equal number macro test variables, first using the ***Eliasson (1978a)***; ***Eliasson (1978b)*** and ***Eliasson and Olavi (1978)*** hands on method, and from the late 1980s using the ***Taymaz (1991b)*** and ***Taymaz, 1993*** computer based method that allows a much larger number of parameters to fit the model to an equally large number of test variables (***Eliasson, 1976b***; ***Taymaz, 1991b***). In both cases the sum of squared deviations was minimized, in the Taymaz calibration program resulting in a very complex loss function. We thus consider the current calibated verson of the MOSES model an empirically credible representation of a Sweden type industrial economy, as are also the simulation studies reported on in this Anthology.[6]

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4. Notably in the initial state. This means that instead of estimation errors, we have measurement errors. On this ***Taymaz (1992b)*** investigated the sensitivity of MOSES dynamical properties to random measurement errors in the initial state and concluded that they should be no problem in medium term simulations.
5. One reason for introducing this option was that we had plans to set MOSES up as a gigantic business game and ask managers from real firms to manage their "twin" firm in the model, competing with all other firms. Such a game required a management instrumentation that was familiar to businesspeople.
6. 47.

In general , the calibrated version of the MOSES model economy responds quite fast to market price signals. It did in the model scenario (see Section 4.3) when the devastating industerial support program was shut down early and drastically, and the highest paid workers in Swedish industry had to find new new and less well paid jobs elsewhere in more productive jobs, and with a minimum of intermediate transactions unemployment. As is also noted in Section 4.3, the real Swedish economy returned quickly to the previous fast growth trends when policies were changed, as suggested both by both the Lindbeck commission in 1993 and by IUI in Andersson et al (1983) . We regarded this as comforting evidence for the specification and calibration of the MOSES model in Carlsson et al 2014.

	REAL	800 REF*	821 Slow	822 Fast	831 Very slow	832 Semi-fast	823	824	825	826	827	828	829	830	1000	1035
DQ	6.4	5.0	4.5	7.1	3.7	3.1	3.8	3.8	4.4	3.8	3.7	3.7	4.7	4.3	5.9	5.6
DL	-1.3	0.8	-0.5	-10.3	-0.2	1.8	0.3	-0.1	0.4	1.3	-0.2	0.4	0.4	0.3	0.8	-0.2
DPROD		4.8	5.5	11.0	4.4	3.0	4.1	4.5	4.6	2.8	4.4	3.8	4.8	4.6	5.9	5.8
DPDOM	6.1	7.0	7.0	9.1	5.8	8.5	5.8	5.8	5.8	7.6	5.8	5.8	6.6	5.8	7.0	7.7
DW	12.7	13.0	16.7	28.1	2.8	13.7	4.4	4.9	6.3	4.3	2.8	3.2	8.8	4.4	14.0	15.7
$\bar{M}$	31.5	40.9	37.9	29.5	47.4	43.5	46.6	46.6	43.9	49.1	47.4	46.8	46.0	46.8	40.8	33.0
A21	7.8	4.4			8.6	4.7									4.1	3.8
A22	6.4	14.1			15.0	15.1									14.5	13.2
RU		6.3			8.9	6.7									5.9	3.3
DPFOR																
Priv.con.	2.7	-0.2														6.0
DGNP	3.1	3.7			2.2	-1.5									4.6	5.7
DCPI	6.4	6.7			6.0	3.2									6.5	7.2
DDI	11.1	6.9			4.4	7.7									7.2	13.1
SAVHR	3.0	3.3			2.0	6.5									5.0	8.3
RI															2.6	6.3
X	31.6	33.3													33.4	29.0
IMP(1+2)	28.6	24.5													25.0	27.4
INV(cur)	8750	7660			6029										11519	
DBW	13.5	14.4			11.2	13.8									19.1	17.7
DNW					5.9	8.6										5.4
DX(vol)					7.5	7.5									10.1	8.8
DM(vol)					2.6	2.0									6.8	9.8
DQ by subindustry																
(1) RAW	6.5	6.4			5.4		5.9				6.5				7.3	7.1
(2) IMED	3.2	5.5			4.7		4.6				5.4				6.6	4.8
(3) INV	6.8	4.1			3.0		2.8				4.3				5.1	4.9
(4) CON	2.5	4.6			2.9		4.7				4.6				5.5	5.7

* For historic experiments in E (1983a) and Figure VIII:4A.

Figure A1. Medium-term tread checks 1960-1975 (8 years).

A.1.6.1. An early calibration example

For the parameters and test variables used in early calibrations see ***Eliasson (1976b)*** republished in this Anthology). For one later run of calibrations on the same model version and the 1976 initial state database (see below) using a larger number of parameters and test variables the test protocols are shown in the tables (from ***Eliasson, 1983***). 26 macro test variables (***Figure A1***) were of interest, the first nine plus inflation (DCPI) trends being prioritized. Ten of the two dozen core parameters (in Figures A2 and A3) were varied to make MOSES economy wide dynamics settle on the prioritized ten 8 year macro trends, before trying to fit the other variables, for instance the parameters regulating firms' expectations. We eventually settled for version 800 in Figure A2. Cyclical variables posed difficulties in the beginning, notably the unemployment variable (RU) which was kept artificially low at 2 percent during this period. In 1983 fits had improved significantly on the cyclical variation (Compare with earlier tests in ***Eliasson, 1976b***).

A.1.6.2. The *Taymaz (1991b) calibration program*

With ***Taymaz (1991b)*** the sophistication of parameter determination was vastly increased. As in ***Eliasson and Olavi (1978)*** calibration meant minimizing, varying model parameters ϴ, the standard weighted sum-of- squared errors between simulated test variables and the corresponding real variables, this time systematically through a large number of automated model simulations. The nature of the MOSES model, however, means that the loss function to be minimized is selection based, highly nonlinear and therefore very complex, meaning the risk of plenty of local minima. Since conventional optimization mathematics is of little use, a random search method has been employed to look for *robust* results in the sense that small variations in parameter values should not significantly change economy wide systems properties. The parameter vector should also be empirically reasonable. The parameter space allowed has therefore been limited on a priori grounds, and it is assumed that it contains the global minimum in its interior. As a first step (*global search*) parameters are randomly assigned within that parameter space. Since they generate information about the global minimum, the shape of the distance curve and influential parameters the number of searches can be terminated when little further information is gained in the next round. There are a number of techniques for that (see ***Taymaz, 1991a***).

The next step of determining a local minimum does not require that it be identical to the global minimum, only that the corresponding parameter vector is close enough, that the model is robust in the neighborhoods of those parameters, and that the long run properties of that parameter vector are reasonable. This second *local search* engages a “hill climbing” algorithm that starts from an initial point, the direction of hill climbing being randomly determined. If the distance value diminishes, parameter values are changed accordingly. Otherwise, a new random direction is selected. This goes on until no further improvement in distance value is obtained. Taymaz uses two options to choose initial value: (1) the result from global search, or (2) the parameter vector currently being used in model simulations. On this we prefer (2) on the presumption that this parameter vector embodies empirically relevant prior information.

As should be obvious, this calibration program is very computer intensive. Computer time increases rapidly with increases in the number of parameters and test variables, and an exhaustive result is not guaranteed in the sense that search has not resulted in a spurious parameter vector. This risk, however, afflicts all estimation methods. As long as the method when applied to new test data *consistently* generates parameter vectors that stay reasonably close or even converge to within a narrowing range, we feel confident in the calibrated parameters obtained. If they begin to stray away, we consider this a reason to check back on model specifications (see Section 3.7).

A.1.7. Testing for distributional characteristics

The ambition of MOSES has never been to predict individual firm behavior, but the capacity of the model to generate realistic distributional characteristics was an early concern, and as soon as sufficient computer capacity became available we began to routinely print out Salter productivity and profitability distributions (***Eliasson, 1984***; ***Eliasson, 1991b***; ***Eliasson, 1991a***), which immediately prompted some respecifications of the model (see Sections A.1.4 and 3.7 above). Early on, ***Taymaz (1992b)*** compared such simulated distributions of, for instance, firm employment, productivity and exports with actual such data for the same firms in the Planning Survey and found a strong correlation, or a narrow spread around a regression line through the origin. Data for more ambitious such tests are now available in the form of long panels of firm data from the Planning Survey, that however need to be properly organized for such tests. For instance, the cohort of identical companies for the whole period is around 90, but during each year upwards of 300 firms were surveyed, covering during the early years more than 80 percent of value added in Swedish manufacturing. For some years a panel of a sample of small and medium sized firms has also been compiled (***Braunerhjelm, 1992***).

The ***Taymaz (1991b)*** and ***Taymaz (1993)*** program can in principle be used to calibrate the model for *distributi0onal accuracy* , even though that would dramatically raise thr the complexity of the loss function and the demands on computer capacity. The panel data sets that have been collected from about 30 years of Planning Surveys can also, when properly organized, be used for such advnced calulations. Such a statistical job is curently being prepared.

Years of experimenting with the MOSES model economy has told us that a viable industrial economy requires distributional consistency to be endogenosusly maintanedand that models that do not endogenously represent that generational market dynamic are of little value to help understand long run macro economic behavior. Macro models should therefore be both micro based and feature expliciut market selection processes.

Abnormal economic systems behavior of the MOSES model early alerted us to *distributional decay* in long run simulation experiments (see above), a consequence that literature hadc nothing to tell about and hence gave no warning of. The reason was excessive exit and insufficient rejuvenation of production structures through firms' investments in new technologies and lack of entry . When endogenous innovation and entry had been activated and structural diversity restored long runstable economic growth was also reestablished (Section 3.7 and ***Eliasson, 1984***; ***Eliasson, 1991b***; ***Eliasson, 1991a***; ***Eliasson, 1995***). That theoretical discovery strongly underlined the need to have explicit market selection

(*Eliasson, 1996a*) and innovative entry endogenously represented in models claiming to explain the long run (Section 2.3). This may sound self-evident, but was not at all at the time. Alerted by MOSES simulations we started to look for distributional decay in the Swedish production system and found a gradual deterioration of structural diversity (a"flattening" of Salter curves in the Planning Survey), signalling that the Swedish economy had been gradually developing a precarious structural state, and that these symptoms, when we alerted policy makres to the facts, were not taken seriously (see for instance Section 5.4).

A.1.8. Master Models

The MOSES model has been regularly upgraded or expanded, implemented on a new data base, and recalibrated/reestimated, to be kept ready as a *master model* that can be *customized* for particular studies. Several such master versions have been set up over the years, and in particular after 1987 when MOSES became PC based. They have been kept archived on old PCs and can perhaps be dusted off to reproduce some earlier studies. Two are currently kept ready for routine studies, one based on the 1982 database but expanded to include a new financial system with capital, stock and financial derivatives markets (*Taymaz, 1999*; *Eliasson and Taymaz, 2001*), and one on the 1997 initial base year, with a fifth IT subindustry micro specified (*Eliasson and Johansson, 1999*).

Since MOSES master models have often been modified no up to date handbook has been maintained. Another problem is that the database contains (see below) some very confidential data. For interested external users a deidentified micro macro SF consistent data base was however generated for 1990 by simulating a recalibrated version of the model forward from the 1982 database,[78] guided by ex post known exogenous variables (*Taymaz, 1991a*).[46] The **five MOSES books** (*Eliasson, 1985*; *Bergholm, 1989*; *Albrecht et al., 1989*; *Taymaz, 1991a*; *Taymaz, 1991b* and *Albrecht, 1992*) should therefore be more than sufficient to carry out simulation studies on that database, using the two master versions of MOSES designed for that code, including the underlying *pseudo code* for the program that is appended *to* this Anthology.

Development of new master versions and new empirical initial states (databases) have often taken place simultaneously.

A.1.9. Databases

Year 1975: First version of MOSES model based on *Eliasson (1976b)* specification, operational in APL code and installed on IBM mainframe on ad hoc compiled 1968 database.

Year 1975: IUI/IVA “Grand Project” collects data on historic development of best practice technologies (Potential productivities) by firms and for four subindustries for periods 1955-1965 and 1965-1975 (*Carlsson et al., 1981*; *Carlsson, 1987*). This data was used to calibrate MOSES model, but also to project future exogenous global development of best practice technologies. See Section 4.2.

Year 1976: Preliminary test data from Planning Survey (*Virin, 1976*; *Albrecht, 1979*; *Albrecht, 1992*) available. Data in Planning Survey makes direct estimation of production frontiers in MOSES firms possible (*Eliasson, 1976b*; *Albrecht, 1978*). First economy wide NA compatible micro macro stock flow consistent database compiled for 1974. Since NA level financial balance sheet data for these early years were not available in Sweden, they had to be constructed from multiple sources, notably within IUI (*Eliasson, 1978a*; *Eliasson, 1992b*; *Eliasson, 1976c*). First parameter calibration of MOSES using *Eliasson and Olavi (1978)* method. *Eliasson (1977)* experiments run on this database.

7. Using the new *Taymaz (1991b)* calibration program, installed on a top of the line PC , the complete calibration process needs about 20 hours of CPU time.
8. To be used for a special study on the role of technical progress and economic competence in economic growth (*Carlsson, 1991*; *Carlsson and Stankiewicz, 1991*).

Initial year 1976: First time Planning Survey data introduced within a complete NA frame. The manufacturing micro sector scaled up to NA level. Historic vector 1974 – 1976 from Planning survey used to determine the price expectations (***Eliasson, 1976b***). For this year it was possible to convert the complete Input Output table for the Swedish economy from its current production taxonomy to the *OECD end use* (and market compatible) classification used by firms in the Planning Survey (***Ahlström, 1978***). The model was recalibrated using the manual ***Eliasson and Olavi, 1978***) method. Calibrated parameters were found to be very close to those using the 1974 database. The new database, and recalibrated model was used for the economy wide cost benefit study of the Swedish industrial support program during the 1970s and 1980s (***Carlsson et al., 1981***; ***Carlsson et al., 2018***).

Year 1977: IBM leaves project. MOSES is transferred from IBM mainframe APL to DEC APL on a DEC -10 mainframe computer in Bergen, made available for free at night by our Norwegian sister institute IØI. The IBM to DEC APL transfer was made possible by a computer language translation program at Columbia University and took place without any problems. For all practical purposes identical output was generated. Hands on recalibration meant no parameter changes.

Initial year 1982: Complete and internally consistent micro (firm) to macro (NA level) database in market, production, labor and financial dimensions. The new database is presented in detail in ***Albrecht (1992)*** *MOSES Database*. Research Report No. 40. Stockholm: IUI. This is the most complete and most carefully compiled initial state description of the MOSES model economy done so far.

Klevmarken, 1984: First year large sample of individual *household income, wealth and consumption data, including data on households' use of free public services, and time spent on various activities* available from HUS project. HUS was an academic data base project partly prepared at IUI, and then funded by the Swedish Central Bank Research Foundation. Questions were to a significant extent formulated to make a future micro specified household sector in MOSES possible (***Eliasson and Klevmarken, 1981***; ***Klevmarken, 1984***; ***Klevmarken and Olovsson, 1993***). By simulating MOSES up to 1984 from the 1982 database an integration of the two databases for 1984 for MOSES studies should be possible, once a C++ MOSES version becomes available (***Lindstenz, 2023***).

Year 1987: Erol Taymaz transfers MOSES from a DEC-10 mainframe version to a Dyalog APL interpreter for a Xenix PC operating system. MOSES recalibrated with minor changes in calculated parameters (***Taymaz, 1991a***).

Initial year 1990: The Planning Survey collects proprietary data on for instance profit margins by division in the large Swedish firms that cannot be made available to external users. A *deidentified complete database* based on the 1982 database has therefore been simulated up to 1990 and made *available for external users* (***Taymaz, 1991a***).

Constructing a complete Micro to Macro stock flow consistent database for 1982 was a major statistical undertaking, as the various source references in ***Albrecht (1992)*** bear witness of. This illustrates the importance of as precise as possible initial state measurements in non linear modeling. Since the economic world to my mind is nonlinear this also clarifies the necessity of good measurement in economics in general.

Year 1992: MOSES recalibrated using new ***Taymaz (1991b)*** and ***Taymaz, (1993)*** global calibration program. Only small variations of calibrated parameters from previous 1987 calibration.

Initial year 1997: For 1997 a completely updated data base, with *a new fifth micro based manufacturing sector/market (the IT subindustry*), was used in the ***Eliasson and Taymaz (2000)*** study of production flexibility in the IT industry for the Swedish Agency for Civilian Emergency Preparedness (ÖCB) and by ***Johansson (2001)*** in his doctorate thesis. The model was recalibrated on new exogenous variables and macro test variables running up through 1997. The critical time reaction parameters of the new expanded model stayed very close to the previous calibration 1987, suggesting that the calibrated parameter vector had not only been *consistently calibrated*, but also located in a uniquely relevant range, suggesting in turn that we did not have to worry that much that a new calibration on new later test data would turn out a completely different set of parameters. The final test of robustness, and the merits of the modular design of the MOSES model would be if a remodeled MOSES with micro household data from 1984 would repeat that consistency (See below and Section 6).

MOSES specification appears robust. Its modular design facilitates upgradings of both specification and databases. The MOSES model has been prepared for making all production sectors, including the public sector micro specified in future.

A.1.10. Model Master Versions (Modular Additions)

Version 1: Documented in ***Eliasson (1976b)*** and ***Eliasson (1978a)***. Not yet economy wide and scaled up to NA level.

Version 2: Documented in ***Eliasson (1985)***; ***Taymaz (1991a)*** and ***Taymaz (1991b)*** but installed gradually from 1978. The model is scaled up to NA level and encased in a complete eleven sector "Leontief" input output production structure, four sectors of which being populated by firms. All incomes generated are fed back after tax (***Eliasson, 1980b***) as "Keynesian" demand. Since the Planning survey collects data on firms' external purchases of input goods and services each firm is now equipped with its own input purchasing table. The long-term investment financing module designed in ***Eliasson (1976b)***: Appendix B) has been introduced. The credit market is still represented by a bank from which firms can borrow at the exogenous global interest rate plus an endogenously determined charge by the bank that depends on local "Swedish" demand and supply conditions. The pseudocode for this version has been reedited by Elias Lindstenz by combining the pseudocode attached to the original version of ***Eliasson (1976b)*** – but not republished in this Anthology – and the extended version published in ***Albrecht et al. (1989)***: Chapter IV). This reedited pseudocode is available online as ***Lindstenz (2024)***.

Version 3: PC version ready in 1987. Endogenous entry (***Hanson, 1986***) and ***Taymaz, 1991a***), and individual firm interest determination introduced (***Taymaz, 1991a***).

Version 3 is identical to the version (then called 7.3) that was transferred from a DEC-10 mainframe to a PC in 1987. Version 3 installed on the 1982 database is thoroughly documented in the five MOSES books.

Version 4: Technological network formation and spillovers (***Carlsson et al., 1997***)

Version 4.2. Firm sponsored training and human capital introduced (***Ballot and Taymaz (1996)***; ***Ballot and Taymaz (1997)***. See further Sect.4.4.

Version 5: Major upgrade. Endogenous technology innovation introduced. ***Ballot and Taymaz (1998)*** and ***Ballot and Taymaz (1999)*** use genetic algorithms. Investments in R&D and in general human capital improve upon globally available best practice technologies. ***Eliasson et al. (2004)*** based on this version and the 1997 database. See further Section 2.3.4.

Version 6: Major upgrade. Capital, stock market and financial derivatives markets introduced. ***Eliasson and Taymaz (2001)*** and ***Taymaz (1999)*** studies conducted on expanded 1982 database.

Version 6.1: Venture capital market introduced. Ballot, Eliasson & Taymaz (2006) study based on expanded 1982 database. See further Section 2.1.

Version 7: Endogenous innovation network formation and expansion of opportunities space. Multi country technology diffusion between cloned MOSES model economies (***Ballot and Taymaz, 2012***). See section 6.

	800	821	822	832	831	823	824	825	826	827	828	829	830	1000	1035	REF*	FAST**
NITER	9	9	18	12										9	9	3	9
KSI	0.15	0.15	0.5	0.3	0.1		0.1							0.15	0.25	0.15	0.25
IOTA	0.5	0.5	0.9	0.6	0.3			0.6						0.5	0.5	0.5	0.5
SKREPA	50	50	50	50	50	50	50	50	50	50	50	50	50	50	5C	75	50
MAXD	0.06	0.06	0.18	0.18	0.03				0.18					0.06	0.06	0.06	0.06
MARKETITER	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
GAMMA	0.1	0.3	0.1	0.1	0.3					0.1				0.1	0.1	0.3	0.01
THETA	0.1	0.1	0.5	0.3	0.005						0.03			0.01	0.01	0.01	0.01
TMX	5	5	1	3	7					3		0.01	0.01			7	3
TMIMP	5	5	1	3	7								3	5	3	7	3

* REF is Reference case in Figure VIII:3.
** FAST is faster labor market policy experiment in Figures VIII:6B.

Note: Parameters are explained in symbol listing to follow.

Source: E 1983a, p.307. Note that these are parameter settings in the stability experiments in Figure VIII:4, also listed in Table VIII:1B.

Figure A2. Parameter settings in the various experiments.

Endogenous variables

Q	= value added, constant prices
L	= labor input (effective labor time)
PROD	= labor productivity
PDOM	= domestic price, industrial goods and services
W	= wage cost level
M	= profit margin
$\bar{M}$	= average profit margin
A21, A22	= capacity utilization measurement, A-B and C-D, respectively (see Figure II:3). Actual development of these variables in planning survey is shown in Figure VIII:2C.
RU	= open unemployment in percent of labor force
PFOR	= foreign price of industrial goods and services (exogenous for four sectors)
Priv.Cons.	= private consumption
DI	= household disposable income (current prices)
SAVHR	= household saving in percent of DI
RI	= interest rate (nominal)
X	= exports in percent of value added
IMP	= ditto for imports
INV(cur)	= manufacturing investment in current prices
BW	= borrowing in manufacturing
NW	= net worth in manufacturing
X (vol)	= export volume
M (vol)	= import volume

Parameters

NITER	= number of searches each firm is allowed in labor market
KSI	= propensity of a firm in search of labor to upgrade its own level (part of wage difference observed) when confronted with another firm with higher wage level
IOTA	= fraction of next year's expected wage increase offered first quarter
SKREPA	= probability (percent) of labor market search leading to pool of unemployed
MAXD	= maximum product price deviation from expected price allowed during year
MARKETITER	= number of adjustments (iterations) in domestic product market
GAMMA	= reservation wage of worker is (100+GAMMA) percent of current wage
THETA	= proportion of a firm's labor force allowed to quit in response to "one search"
TMX	= export supply price elasticity. 1/TMX is fraction of domestic-foreign price gap planned to be closed first year
TMIMP	= Ditto, imports

Figure A3. Symbols used in Tables.