

# The life and career of Karl H. Borch<sup>1</sup>

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Developments in insurance economics over the past few decades provide an illustration of the interplay between abstract theorizing and applied research. In this connection early contributions of Karl Henrik Borch, from the late fifties on, are noteworthy.

Karl Borch was born in Sarpsborg, Norway, March 13, 1919. He graduated from high school in 1938 and started working in the insurance industry at the same time as he commenced his undergraduate studies at the University of Oslo. He got his education interrupted by the Second World War, and in 1941 he fled to London. Here he was first attached to the Norwegian exile government, working in the office of foreign affairs. Later he spent three years with the Free Norwegian Forces in Great Britain. When he returned to Norway after the war, he graduated with a master of science in actuarial mathematics in 1947.

After his graduation Borch was hired by the insurance industry, but only for a short time: In August 1947 he became a Science Liaison Officer at UNESCO, serving in the Middle East, a position he held till 1950. New UN-appointments followed, first as Technical Assistance Representative in Iran during 1950-51 and then back to UNESCO, now in the southern part of Asia, in 1952. The years 1953-54 he represented UNICEF in Africa, south of Sahara. From 1955 till the summer of 1959 he was with the OECD in Paris as director for this organization's division of productivity studies.

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An exception from this kind of career occurred in the spring semester of 1953, when he spent as research associate at the Cowles Commission for Research in Economics at the University of Chicago, at that time the leading center in the world for the application of mathematical and statistical methods in economic research. Here he met some of the world's leading, and also young and promising economists. Based on this visit he published an article in *Econometrica* - the leading journal for quantitative economic research – about the effects on demand for consumer goods as a result of changes in the distribution of income (Borch (1953)).

In 1959 he came at the Norwegian School of Economics and Business Administration (NHH), located in Bergen, via a donation of a chair in insurance. First Borch was given the scholarship associated with the chair, used this period to take his doctorate at the University of Oslo in 1962, and was finally appointed professor of insurance at the NHH in 1963, a position he held until his death on December 2, 1986, just barely before retirement at pensionable age.

Borch started his new career with enthusiasm. In *Who's Who in Economics* (2. Ed. 1986, 3. Ed. 1999) he writes: “When in 1959 I got a research post which gave me almost complete freedom, as long as my work was relevant to insurance, I naturally set out to develop an economic theory of insurance”. Sounds simple and uncomplicated. Within a relatively short period of time he managed to employ the new, and at the time rather abstract equilibrium theory in economics to bring out the essence of the benefits to risk sharing in insurance. Borch's formulation of this problem was also appreciated within the economic discipline, which put him on the map as one of the leading scholars in his field.

Borch knew the recent theoretical papers of Allais (1953a-b), and especially Arrow (1953), and the subsequent reformulation of general equilibrium theory by Arrow and Debreu (1954). He was also aware of the von Neumann and Morgenstern (1947) expected

utility representation of preferences. He understood their significance as well as their limitations, at a time when very few economists had taken notice. As he explained more explicitly in 1962, he attributed that lack of recognition to the fact that these “relatively simple models appear too remote from any really interesting practical economic situation... However, the model they consider gives a fairly accurate description of a reinsurance market.”

One important contribution in the papers by Karl Borch in *Skandinavisk Aktuarietidskrift* (1960a) and *Econometrica* (1962) was to derive potentially testable implications from the abstract model of general equilibrium with markets for contingent claims. In this way, he brought economic theory to bear on insurance problems, thereby opening up that field considerably; and he brought the experience of reinsurance contracts to bear on the interpretation of the theory of syndicates in economics, thereby enlivening the interest for that theory. In fact, Borch’s model is complete by construction, assuming that ‘any’ reinsurance contract can be negotiated, so he seemingly did not need the rather theoretical, and non-existing market for of Arrow-Debreu securities (Arrow and Debreu (1954)). This formulation of the model was appealing since contracts exist in the real world, and opened up for important insights.

However, the Arrow-Debreu-securities are still needed for the equilibrium formulation of the risk-distribution problem. Since there are no transaction costs or other frictions in this model, premiums must be linear functionals. Instead of simply using the Riesz’ Representation Theorem, Borch struggled with Fourier transforms and associated cumulants. This may be formally correct, but prevented him from bringing forth the pricing part of the problem in an easy and lucid manner.

Borch was influenced by the subjective expected utility representation proposed by Leonard Savage (1954), and was early on aware of Bruno de Finetti’s fundamental theories, e.g., de Finetti (1937). Here the preference relation is defined directly on a

set of objects, called acts, which is typically more suitable for many purposes, certainly for those of Borch, than having this relation defined over a set of lotteries, as in the von Neumann-Morgenstern representation. He wrote a really entertaining paper in the Bayesian tradition, “The Monster in Loch Ness”, published in the *Journal of Risk and Insurance* in 1976.

Borch did not write only about insurance, but when addressing broader economic issues, the uncertainty part was usually essential. He was mainly concerned with the one-period framework, with consumption only at the end, in which case consumption equals wealth. Accordingly consumption substitution across time was not any issue of interest to him, so he was not concerned with preference relations over consumption sequences. Here Jan Mossin (1969) had discovered that the additive and separable expected utility representation was in violation with the axioms (the substitution axiom), when consumption takes place at more than one point in time, and there is uncertainty involved.

Many of his thoughts around the economics of uncertainty were formulated in his successful book “**The Economics of Uncertainty**”, published in 1968 by *Princeton University Press* (also available in Spanish, German and Japanese). The background for this particular work is rather special: Borch was visiting The University of California, Los Angeles, where he was about to give a sequence of lectures in insurance economics. The topic did not seem to attract all that much attention at the time, and only a few students signed up for the course. Then Borch changed marketing strategy, renamed the course “The Economics of Uncertainty”. Now a suitably large group of students turned out, the course was given, the contents changed slightly, and the well-known textbook resulted. This illustrates the close connection between economics of uncertainty and insurance economics, at least as seen from Karl Borch’s point of view.

In his subsequent publications, Karl Borch often related advanced theoretical results to casual observations - sometimes in a genuinely entertaining manner, (as the paper “The Monster in

Loch Ness” illustrates), which transmits to younger generations a glimpse of his wit and personal charm. Several papers by Karl Borch follow a simple pattern: after a brief introduction, the first-order conditions for efficient risk-sharing were formulated, then applied to the problem at hand; the paper ends with a discussion of applicability and, if possible, a confrontation with stylized facts. The author preferred an informal discussion, to formal theorems and lengthy elaborations.

Borch enjoyed connecting the theory of reinsurance markets and the “Capital Asset Pricing Model” (CAPM), developed by his former student Jan Mossin, among others (Mossin (1966)). Although Borch realized the restrictive nature of the assumptions underlying the CAPM, he often used that model as an illustration, stressing that “the applications of CAPM have led to deeper insight into the functioning of financial markets” (e.g., Borch (1982), (1983a), (1990, ch.3)).

There is a story about Borch’s stand on “mean-variance” analysis. This story is known to economists, but probably unknown to actuaries: He published a paper, “A note on Uncertainty and Indifference Curves” in *Review of Economic Studies* (1969), and Martin Feldstein, a friend of Borch, published another paper in the same issue on the limitations of the mean-variance analysis for portfolio choice (Feldstein (1969)). In the same issue a comment from James Tobin appeared, “Comment on Borch and Feldstein” (Tobin (1969)). Today Borch’s and Feldstein’s criticism seems well in place, but at the time this was shocking news. In particular, professor James Tobin at Yale, later a Nobel laureate in economics, entertained at the time great plans for incorporating mean-variance analysis in macroeconomic modelling. There was even financing in place for an institute on a national level. However, after Borch’s and Feldstein’s papers were published, Tobin’s project seemed to have been abandoned. After this episode, involving two of the leading American economists, Borch was well noticed by the economist community, and got a reputation, perhaps an unjust one, as a feared opponent.

It may be of some interest to relate Borch's view of the economics of uncertainty to the theory of "contingent claims" in financial economics, the interest of which has almost exploded, following the paper by Black and Scholes in (1973). In order to really understand the economic significance of these developments, it is well worth to study the theory in Borch's language (e.g., Borch (1968a-b)), where many of the concepts are more transparent than in the "modern" counterpart, at least as it was originally formulated. For example, Karl Borch made important, early contributions towards the understanding of the notion of complete markets as earlier indicated (e.g., Borch (1962), (1982), (1983a-b)). And the linear pricing rule preventing arbitrage is the neoclassical one just as in Borch's world, where the main problem is to characterize the "state price deflator" from underlying economic primitives (Borch (1962), (1982), (1985), (1990), among others). As mentioned before, at this point Borch did not bring the theory quite to its final form, but this is pioneering work. In optimum the state price (in units of probability) is equated to the marginal utility of consumption, which is where preferences enter into the pricing relationship.

Much can be said about Karl Borch's importance for NHH. When he started as a professor there was an expansion period, which transformed the School from a small to a relatively large institution of its type. For the generation of researchers who got attached to NHH as research assistants in this period, Borch had a significant influence – as teacher, advisor, and as a role model. He gave the first lectures at graduate level, and was advisor for several master's (licentiat) and doctoral candidates. As advisor he stimulated his students to study abroad, and using his broad network of international contacts he helped them to get to good places. He also encouraged them to attempt international publishing. For his collected activities as a professor, in 1986 he received the NHH Price for Excellent Research, then awarded for the first time at the School's fiftieth anniversary.

Karl Borch was member of a number of professional organizations. He took part in their activities and presented his thoughts in lectures, discussions and written contributions. After Karl Borch had participated for the first time at the third meeting of the *Geneva Association*, held in Geneva in June of 1973, he became a driving force behind the maturation, extension, and the credibility of this group. In 1990 this association honored his memory by publishing the volume *Risk, Information and Insurance, Essays in the Memory of Karl H. Borch*, Kluwer Academic Publishers. The consistent quality of his contributions led to his invitation to present the fourth “Annual Lecture” in 1980 entitled: “The Three Markets for Private Insurance”, a series of lectures organized by the Geneva Association. This series, by the way, was inaugurated by Kenneth Arrow in 1977, and benefited from the contribution of various world-known economists such as Martin Feldstein, Joseph Stiglitz, Edmond Malinvaud, Robert Merton, Jacques Drèze, and others.

Karl Borch was once invited to the *Royal Statistical Society* in London, where he presented “The Theory of Risk”, published with discussion in their prestigious scientific journal; *Journal of the Royal Statistical Society*, Series B, (1967). Here, among other things, he relates his findings to de Finetti’s “collective theory of risk” (de Finetti (1957)). He also made some efforts to find the ‘optimal’ dividend policy of an insurance company. This was a problem that he returned to on different occasions later, but eventually (in 1981) he discovered that the problem simply did not have any interesting solution under the assumptions of his model (the content of one of the Miller and Modigliani-theorems (1961), established many years earlier).

During his period as a professor, from 1962 till his untimely death in December 1986, he had more than 150 publications in scientific journals, proceedings and transactions from scientific conferences, among them three books (Borch (1968a), (1974) and (1990)). In addition to what has already been said, it should be mentioned that his pioneering work on Pareto-optimal risk

exchanges in reinsurance (e.g., Borch (1960a-b-c), (1962)) opened a new area of actuarial science. This research field offers a deeper understanding of the preferences and behavior of the parties in an insurance market. The theory raises and answers questions that could not even be put into shape by traditional actuarial handicraft: how can risk be optimally shared between economic agents, how should the insurance industry best be organized in order to further social security and public welfare?

In developing this theory, Borch turns to what he calls the “Bernoulli hypothesis”, what might be better known to a younger audience as the expected utility theorem. He discusses the pros and cons regarding the axioms of this theory, but dismisses these controversies in the context of a reinsurance, stating: “there is no need to take up this question here, since it is almost trivial that the Bernoulli hypothesis must hold for a company in the insurance business.”

Today one may, perhaps, add that applied to a syndicate with the individuals represented by people, this is probably fair enough. But applied to insurance *companies*, the assumption about decreasing marginal utility of wealth may not seem all that realistic. For an individual, this is the same as risk aversion. But risk neutrality in the standard model would not work either.

In our time various theories are being developed to address these issues – but hopefully with inspiration from the early pioneer in the field. For example, Borch’s theory can explain the existence of proportional reinsurance contracts, but cannot explain the even more common Excess of Loss (XL) reinsurance contracts, containing tranches. These contracts are also occurring in other fields of finance. XL-contracts cannot emerge from the standard theory, since the first order conditions do not depend on probability distributions. On this point the dual theory of choice under risk by Yaari (1987) may offer a plausible explanation.

Finally, it should be mentioned that Borch gave several contributions to the application of game theory in insurance (see e.g. Borch (1960b), (1960c), (1974)). With his clear intellect



Borch was typically attracted to game theory. In particular he characterized the Nash bargaining solution (Nash (1950)) in a reinsurance syndicate (Borch (1960c)), and also analyzed the moral hazard problem in insurance (Borch (1980)) by a Nash equilibrium in mixed strategies (Nash (1951)), among many other applications.

Some of his articles have been collected in his book *The Mathematical Theory of Insurance* (1974), Lexington Books (with a foreword by Kenneth J. Arrow). His output averaged more than six published papers a year as long as he held the chair in Bergen. At his death he was working on a manuscript to a fundamental textbook in the economics of insurance. This manuscript, supplemented by some of Borch's papers, was later published as *Economics of Insurance* (1990), North Holland, with the help of professor Agnar Sandmo and myself. This book was translated into Chinese in 1999.

Karl Borch will be remembered by colleagues and students at the NHH and in many other places as a great scholar and as a pioneer in the theory of risk-sharing.

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