

# Extended Preface: A Realistic Attitude to the Economy

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I have one regret in writing this little chapter to accompany Karl Mittermaier's book, which is that I never met him. There are many things on which we clearly agreed and many others that I would like to have discussed with him. What is most interesting is that he tackles the fundamental problems of economic theory, the role of time, the nature of equilibrium, what sort of theory could be developed to deal more satisfactorily with these head on. He links these problems with the contributions of a host of predecessors. But, of course, in attempting to do this he did not himself claim to have produced an all-encompassing theory but rather point out what elements such a theory would need.

## 1. Philosophical considerations

His philosophical bent shows through on practically every page of this book, and he was fascinated by debates in that discipline.

For instance, he spent considerable time on the notion of free will and the debate as to its importance in economics. He characterized two approaches as to how free will enters into the economic picture. The usual discussion as to the nature and role of free will in economics boils down, in his view, to a debate between two different positions. On the one hand there is the 'complexity' approach, which argues that the whole system is 'too complex' for the human mind to grasp and that therefore the future remains essentially unpredictable. The alternative position is associated with the free-will approach. This could be reduced, as Mittermaier explains, to arguing that the only obstacle to explaining the whole system and its functioning is that human action intervenes. This is too simplistic a summary of his view, but his reflection on the subject was enough to lead him to reject the pure free-will argument.

Another debate which particularly interested him was that about nominalism.

Michael Stettler (2019) says that one of Mittermaier's favourite quotes was that where Pareto called himself 'the most nominalist of nominalists'. For Pareto, all good science has to follow the nominalist path, purging itself of any metaphysics. And so, Mittermaier chose as the epigraph for one of his unpublished manuscripts the following from Pareto's (1935) *Mind and Society*:

Literary economists ... are to this day dilly-dallying with speculations such as 'What is value?' They cannot get it into their heads that things are everything and words are nothing, and that they may apply the terms 'value' and 'capital' to any blessed things they please, if only they be kind enough – they never are – to tell one precisely what those things are. (Pareto, 1935, p 62)

To a non-philosopher, this recalls a famous quotation from *Through the Looking Glass* and often attributed to the Red Queen but actually uttered by Humpty Dumpty:

'When I use a word', Humpty Dumpty said, in rather a scornful tone, 'it means just what I choose it to mean—neither more nor less'.

'The question is', said Alice, 'whether you can make words mean so many different things.'

'The question is', said Humpty Dumpty, 'which is to be master—that's all'.

But Mittermaier was not just playing with the notion of nominalism and was, in fact, developing a realist approach in which facts play a central role and he was not on the same wavelength as the 'dogmatic' economists who were content with abstractions rather than reality.

## 2. His approach to economics

But now I should turn to the central part of his contribution.

Much of his discussion turns around the possibility of an omniscient Laplacean view of the world in which there are, in reality, well-defined causal relations, and where prediction and explanation of past events are just mirrors of one another, there being no place for chance and coincidence. Economists' attempts to achieve this omniscience are well summed up by Sargent's remark about rational expectations: 'All agents inside the model, the econometrician, and God share the same model' (Sargent, 2005, p 3). To this could be added Mike Woodford's observation:

It has been standard for at least the past three decades to use models in which not only does the model give a complete description

of a hypothetical world, and not only is this description one in which outcomes follow from rational behavior on the part of the decisionmakers in the model, but the decisionmakers in the model are assumed to understand the world in exactly the way it is represented in the model. (Woodford, 2012, p 2)

The modellers are thus attributing much greater cognitive power to those whom they model than to themselves. Woodford is clearly sceptical of these hypotheses and, like Mittermaier, does not see people that inhabit real economies as the omniscient individuals who are portrayed in standard macro-economic models.

### **3. Is rationality inherent, learned, or something that is not a characteristic of ordinary individuals?**

The notion of rationality lies at the heart of much of Karl Mittermaier's thinking. He clearly thought that the basis for any economic theory should come from what he called *ex ante* facts rather than *ex post* facts. This distinction, which might puzzle some people, is, if I understand him correctly, based on the idea that there are some regularities in the process that governs the evolution of an economy but many of the data from the past are not of much use in helping us to understand the general structure of the economy and, even less, to be able to predict the future of that system. However, he shared Hayek's view that there are recognizable 'patterns' which recur, and which do help us to fathom the nature of economic activity. Yet he thought that the structure that economists have hung on the *ex post* data was not only unsatisfactory but probably wrong. To put things simply, suppose that we try to explain past developments in economic activity as being the result of individual optimization over the alternatives available to them. So, individual self-interested optimization would be the axiomatic basis for the analysis of economic outcomes. But why use the term 'axiomatic'. This comes from the desire of economists to place their discipline in a framework which could be treated mathematically, and within which one could 'prove' results.

The framework that emerged with the marginal revolution and honed to perfection by Arrow and Debreu (1954) was based on a series of assumptions that were certainly not drawn from reality and when examined closely, as Herb Simon was fond of pointing out, had little to do with how people actually behave. Mittermaier had little time for the assumptions normally made by economists about people's preferences. He had penetrating insights about the nature of those preferences and the space over which they were defined. His discussion of the consistency of preferences is particularly interesting.

#### 4. *Ex post* and *ex ante* facts

As I have said, Mittermaier put great emphasis on ‘facts’, but the terms *ex ante* and *ex post* are likely to puzzle some. How can one see this distinction in economics? My view is that Mittermaier was expounding an idea that has been taking shape through a variety of channels but that, rather than modify some of the arguments that were out there, he constructed something which he found satisfactory, but which uses terms that can cause confusion. When he talks about the *ex post* facts that one uses to construct explanations or stories to explain the past, he clearly denies the idea that we can extrapolate from that set of facts to predict the future. Why is that? It is because what happened is not only what results from the deterministic effects from certain causes but is also conditioned by chance and coincidence. One cannot, he argued, extrapolate from these random occurrences. Hence the evolution of the economy is globally unpredictable. He asserts that, nevertheless, there are recurrent patterns and, in this, he joined Hayek who asserted that ‘there are no laws in economics just patterns’ and the job of the economist is to recognize those patterns. Mittermaier leaves us in a halfway house. The world, he says, is not deterministic and does not approach the physical sciences in that respect. However, the world is not totally without structure, and we should pragmatically seek to understand that structure. Econometrics seems to have pursued this route by postulating deterministic models which are subject to the influence of ‘noise’ where that noise is responsible for the ‘deviations’ from the deterministic path that the system would have followed. As soon as we accept this then we are on the road to adopting the structure that I have mentioned which can be thought of as a deterministic model which is persistent and is just perturbed by the noise or exogenous shocks.

However, as a number of people have pointed out, the underlying assumption which justifies this is what is called the ‘ergodic hypothesis’. This says that a process is ergodic if the probability distribution of the states through which it passes over time converges to the probability distribution over the states in which it might find itself at any point in time. If you ran the process many times and, each time, recorded its state at one particular point at time the distribution that you would get would be the same as if you had run it for an infinite time.

It has frequently been observed that ‘the world is not ergodic’, and it has been argued that without this assumption prediction is not possible. Samuelson said, for example, that without the ergodic hypothesis economics becomes ‘just history’. The argument about the importance of ergodicity in economics became quite fierce with interventions from [O’Donnell \(2014\)](#) and [Davidson \(2015\)](#) for example. The argument turned to a considerable extent as to what Keynes’s opinion or position was on the nature of

uncertainty. I have the impression that Mittermaier was walking gingerly around this idea but without directly referring to the notion of ergodicity.

## 5. Realism

When discussing the apparent failure of economists to take a realistic attitude to the economy that they are analysing Mittermaier quotes Eddington who chastises physicists for having been ensnared in the technicalities of their discipline as opposed to interesting themselves in the actual phenomena with which it should be concerned.

This vagueness and inconsistency of the attitude of most physicists is largely due to a tendency to treat the mathematical development of a theory as the only part which deserves serious attention. But in physics everything depends on the insight with which the ideas are handled before they reach the mathematical stage. (Eddington, 1939, p 55)

Here one can think of the echoes from Marshall,<sup>1</sup> far from the approach that modern economic theory has taken. The use of mathematics should not, according to many mathematicians, be confined to looking around for some existing results which might be convenient to solve the problem at hand but should play a more creative role. To cite a very well-known mathematician, Sarah Hart,<sup>2</sup> the Gresham professor of mathematics:

Real mathematics involves not knowing what is going on, not having any idea what to do, and then playing around and hopefully finding your way through. Finding the way often involves imposing structures and constraints on a problem. The tension is between wanting the most general result possible and actually being able to prove something. You could prove hundreds of rubbish theorems about your very precise special case, but nobody would care because it has no wider implications or applications. You want just enough structure to hang your ideas on, but not so much that you are boxed in. (Hart, 2021)

What she suggests is that, rather than imagining some abstract framework, what one should do is to look for some framework that has some basis in reality and to hang one's hat on that. I think that this would be much more in keeping with Mittermaier's vision than what he described as the 'dogmatic' approach. Indeed, I feel that he was looking for ways of making economic theory 'better' and that this could not be done by making small modifications to the model that we inherited from our enlightenment ancestors. Intellectually, I do not see him as a 'classical liberal' though, for all that I know, that expression might catch some of his general philosophy.

## 6. Preference fields

Among the building blocks of modern economic theory preferences play a central role and Mittermaier discusses their nature at length. Anyone who has looked at modern micro-economics knows that we impose extraordinary conditions on them, such as they are defined over a space of goods or services, for the most part taken to be Euclidean, and have the properties of reflexivity, transitivity, continuity, monotonicity, convexity and so forth. None of these assumptions would seem plausible to an uninformed bystander but one can look at it from the other side and observe that with all these assumptions one can derive a certain number of results. But they are, of course, at best some sort of abstract approximation which allows us to formalize the idea that individuals when they choose do maximize something.

I suspect that transitivity was about as far as Mittermaier wanted to go and that he regarded the rest as providing the structure for the maximization exercise that individuals are presumed to do. But, even if we did accept that people have preferences over the alternatives available to them, then we are not really requiring that they have them over all the possible alternatives that might be available to them. In fact, to do so makes the problem much more complicated.

It would entail dealing with an infinite number of goods unless we were prepared to endow people with a finite life. But to do the latter would also mean stipulating who is alive when and who are the others with whom exchanges and agreements can be made. As it is, as has often been said, the whole framework is set up at time zero and the world either unfolds in a purely deterministic way or the individuals make their decisions at time zero and the world evolves in a stochastic way, but a way which is mysteriously understood by the participants.

But if individuals are to make decisions, at the outset, they must know which alternatives are available to them. This means that there must be constraints. But where do those constraints come from? In the Walrasian model there is some actor who announces the rates at which units of commodities can be exchanged with each other, that is this actor announces prices which are observed by everybody. This actor is commonly referred to as the 'auctioneer' even though, as Walker (1996) has clearly shown, Walras never used the term. Once prices are announced, in this admittedly over-simplified model, people can then know the value of their own goods and this defines their budget or wealth, or income. The two being equivalent in this case. The individuals can then choose their actions and acquire and divest themselves of goods so as to obtain the most satisfying bundle to which they have access. When the prices are such that what is demanded of every good is just equal to what the participants in this economy are willing to supply,

there is equilibrium. What I have just said involves major restrictions on the behaviour of the agents and on the institutional structure of the economy.

## 7. The problems

First of all, consider the fact that in any system in which agents interact, that interaction will influence people's choices and even a detailed study of an individual in isolation will tell us little about the aggregate outcomes. We are dealing with a complex system and, if there is one thing that has become clear, it is that one cannot simply derive aggregate behaviour from our knowledge of the individual components of the system.

Nobody believes that the framework that I have just outlined corresponds to any market that exists or has existed. The only reason that we have reached this point is our desire to construct a global model which can be solved, and which has to be a drastically simplified one to be solvable. But the easiest way to do this was to make the step from the individual to the aggregate directly whereas there were clear warnings that this was erroneous.

To cite Robert Laughlin, a Nobel laureate in physics:

I am increasingly persuaded that all physical law that we know has collective origins, not just some of it. In other words, the distinction between fundamental laws and the laws descending from them is a myth. ... Physical law cannot generally be anticipated by pure thought, but must be discovered experimentally, because control of nature is achieved only when nature allows this through a principle of organisation. ... What physical science has to tell us is that the whole being more than the sum of its parts is not merely a concept but a physical phenomenon. Nature is regulated not only by a microscopic rule base, but by powerful and general principles of organisation. (Laughlin, 2005, Preface)

In a similar vein Phil Anderson, another Nobel laureate in physics, said:

The ability to reduce everything to simple fundamental laws does not imply the ability to start from those laws and reconstruct the universe. In fact the more the elementary particle physicists tell us about the nature of the fundamental laws, the less relevance they seem to have to the very real problems of the rest of science much less to those of society. ... Instead, at each level of complexity entirely new properties appear and the understanding of the new behaviours requires research which I think is as fundamental in its nature as any other. (Anderson, 1972, p 393)

Where have we got to in our search for the overall model? Can we continue to satisfy ourselves with a framework that ignores the problem of aggregation. If, as these quotes suggest, aggregate outcomes are somehow intrinsically different from individual ones then much of standard economic theory built on ‘sound micro-foundations’ will not be satisfactory. This seems to be to be one of the major flaws of modern theory.

## 8. Coalitions and their role: an insight from game theory

The basic idea of the ‘Invisible Hand’, which is the focus of Mittermaier’s other book, is that there is some mechanism which yields ‘satisfactory’ allocations of the resources with which the economy is endowed, and this mechanism is referred to, in a distortion of what Adam Smith actually said was ‘The Invisible Hand’. The underlying reasoning is that a group of individuals acting in their own interests will self-organize into a state which has, from a global point of view, ‘good properties’. As Mittermaier points out, what the set of possible outcomes is and the criteria for deciding which of them are desirable depends very much on the structure that one imposes on the economy. The easiest framework is that which has traditionally been used in the modern neo-classical picture of a market or economy and is what is referred to as an ‘exchange economy’ and Mittermaier uses it as a starting point for his discussion of what constitute satisfactory outcomes. In an exchange economy what is involved is a world in which there is a fixed number of goods and a fixed amount of each of them, which can be allocated among a fixed number of individuals each of whom has given preferences over bundles of these goods. The goods are initially held by the individuals and are referred to as their ‘endowments’. Think of a marketplace in which producers of different goods bring these to the market to sell and wish also to buy other goods to satisfy their wants or needs. Some assumptions are made about the preferences of the participants in the market. For example, it is assumed that people prefer more to less of any good, that if they prefer bundle  $x$  to bundle  $y$  and bundle  $y$  to bundle  $z$  then they will prefer bundle  $x$  to bundle  $z$ , (transitivity) these assumptions are held to define what is ‘rational’. The question, then, is which allocations in such a framework are satisfactory?

Within the simple example of an exchange economy there are two obvious candidates for the set of aggregate outcomes. One is the familiar idea of a Pareto optimum, an allocation of all the goods to the individuals where no reallocation of those goods could make somebody better off without making someone else worse off. There are many such outcomes, indeed, from several points of view, too many. Another is the so-called ‘competitive equilibrium’, which introduces the notion of price. Suppose that in the marketplace each good has a price and that everyone in the market knows



those prices. Then, each participant can calculate the value of the goods they bring to the market, and this constitutes their wealth, often referred to as their 'income'. Then the individual knows that they can purchase any bundle of goods which has a value less than that of their income which they will spend in return. If prices are such that the total quantities of the goods demanded (aggregate demand) is just equal to the quantities of the goods brought to the market (aggregate supply), then the result is a competitive equilibrium. We can easily show that a competitive equilibrium is a Pareto optimal allocation, and it is, of course, one that makes some sense from an economic point of view.

However, finding a restrictive set of allocations which had satisfactory properties was not useful for answering the basic problem that Mittermaier posed. Even if the allocations mentioned might be satisfactory, what is important is to know how they might be attained. Mittermaier wanted to find an approach which would provide an answer to that question. He was convinced that arriving at reasonable allocations of goods involved groups with particular affinities. In other words, it is not just a mechanical allocation depending on some prices determined by some anonymous actor but rather an agreement among like-minded individuals which sustains the arrangement. It is intriguing that Mittermaier, in this search for ways of defining satisfactory outcomes for an economy, should have hit upon the notion of the core. This is a 'solution concept' which gave rise to a large but very abstract literature. Given his background and his philosophical bent it might seem odd that a concept from game theory would come to his mind. Perhaps even more so because one should always keep in mind that when people are talking about this type of allocation they are typically talking about a purely static concept. Yet, Mittermaier was also looking for some sort of procedure which would lead to the acceptable allocations. It is here, in my view, that Mittermaier showed that he had not only found allocations which were satisfactory from the global point of view but ones which could be thought of as emerging from collective behaviour.

To explain, let me first describe what is meant by a core allocation. Think of any arbitrary allocation of goods to the participants in the simple exchange economy I have already described. Now this will specify which 'bundles' of goods will be received by which of the participants. This is, as if all the endowments of the community in question were put together in one place and then someone would suggest a reallocation of those goods among all the participants. Then the question is asked, 'Does any individual or group have an objection to this allocation?'. By this is meant, is there any individual or group who could withdraw their initial endowments from the collective heap and then redistribute them either to him or herself or to the members of the group so that they are made better off than in

the original allocation proposed? If this is the case, then the individual or group in question can make an objection to the allocation proposed. Any allocation to which no individual or group has an objection is in the core. In the literature that developed around this notion it was originally assumed that any coalition could object to (or ‘block’) a proposed allocation. This meant that any allocation in the core is Pareto optimal since if this were not the case the coalition of the whole community could block it and improve everyone’s welfare. Furthermore, it is easy to show that any competitive equilibrium allocation is also in the core (see Hildenbrand and Kirman, 1988). This is interesting because no mention is made of prices in defining the core. A standard objection to the usual Walrasian equilibrium is that there must be someone who calls out the prices which are then taken as given by all the market participants, and the typical explanation is that there is a ‘commissaire priseur’ or auctioneer who does this. So, this is far from the usual characterization of a perfectly competitive Walrasian market as one governed by a decentralized procedure.

What stimulated so much interest in the core was that, although it involved no mention of prices, it was possible to show that in large economies, in terms of the number of agents the only allocations in the core were the competitive equilibrium allocations. So, an increase in the number of economic agents made the core ‘shrink’ to the set of competitive equilibrium allocations without prices ever entering the scene.<sup>3</sup>

But – and here I see evidence of a remarkable insight of Mittermaier – he contemplated how the core allocations might actually be generated by some collective arrangement. He thought that it was unreasonable to think in terms of arbitrary coalitions as removing unsatisfactory allocations but rather thought that one should only consider coalitions which might have a realistic possibility of forming. Several of us played with the idea of putting restrictions on the coalitions that could appear, but as in Kirman et al (1986), we thought of individuals as being in a network and only allowed them to form coalitions if they were close to each other. For example, one could limit the coalitions to groups of individuals all of whom were directly linked to one another. Or could require that for any two people to be in the coalition, they must both be linked not necessarily to each other but to someone else in the coalition, that is they should have a ‘common friend’ in the coalition. But this is still very abstract, for what is not described is the nature of the links and what is necessary, as Mittermaier realized, is that the underlying network should have some sociological or economic reasoning for existing. For this we can exploit our knowledge of people’s family, religious or other ties. It is, of course, much more plausible to approach the problem like this rather than to assume an arbitrary network. Such an idea would be consistent with some of the Austrian writers in whom Mittermaier showed such interest. But one could also trace such an idea to Pareto with his theory

of the ‘Elites’ who, when they were in power, would eliminate allocations of resources which did not favour themselves.

To take Mittermaier’s idea seriously we should specify what is meant by closeness, that is, we should define a metric over the set of all the participants in the economy or market we are discussing. The usual metric in a graph is the number of links between two participants; the measure of how well connected the whole graph is, is that one takes the number of links between the two participants that are the least well connected. This is the so-called diameter of the graph. Now suppose that we do not know the structure of the whole graph, but do know the probability that any two participants will be linked to each other. So, the relations between individuals are stochastic. This is much more plausible than the idea that we know the details of all the links. As we look at larger and larger graphs the probability that any two individuals will be linked should decrease. A remarkable result of Bollobás (1985) shows that if this probability does not go to zero too fast as  $n$  the number of participants in the group increases then finally the diameter of the group will be 2 with probability 1. In other words, every pair of individuals in that group will have a common friend who is in the group. Thus, a very large coalition will be very tightly linked. This is counter-intuitive since when two people meet who do not know each other but find out that they have a common friend, their usual reaction is to say, “Oh, it’s a small world”, whereas they should conclude the opposite, that the world is large. Now how does all of this link with Mittermaier’s ideas about coalitions?

Well, what is being discussed is what defines or characterizes a coalition and the idea is that its members have something in common which links them together but using the word ‘coalition’ does not avoid the problem, for in the way Mittermaier was thinking of a coalition, it was less some common characteristic but rather some common purpose that brings the members together. They get together because it is in their common interest to do so.

But here we are back to the nominalist debate. Calling them a coalition rather than a group or family does not change that.<sup>4</sup> As Stettler (2019) in his analysis of Mittermaier’s philosophy points out, Darwin took this ‘nominalist’ position when he talked about species, arguing that the actual term had no significance without reference to some physical property. Pursuing that line of thought one can interpret the expression ‘it does not matter’ in a similar way. Or to go further as Oscar Wilde said, ‘Nothing matters very much and most things don’t matter at all.’

But why was this digression about the core and its properties justified. For me, this is a perfect example of Mittermaier’s approach. Although he was clearly influenced by those whom he met or read he was an essentially independent thinker and one who followed a trail where it led. So, in arguing that the use of a game theoretic notion could help to fill one of the most important gaps in economic theory, he was ‘thinking out of the box’.

He seems to have had in mind that the common interests of people in a coalition, or whatever one would like to call it, would lead them to reject material arrangements which could be changed to improve their collective welfare. How this would happen and what institutional arrangement would facilitate this is not stated. However, Mittermaier was evidently trying to find a way in which the satisfactory outcomes that the Invisible Hand was supposed to produce could actually be generated. The appeal to the idea that individuals with common characteristics or goals might act together to obtain what they want or, at least, to prevent things that they did not want does not seem unreasonable. It remains to be specified through what social process this would happen. Here Mittermaier was pursuing one of his important themes, the notion that people's preferences are strongly conditioned by the institutions of the society in which they exist. Again, as he points out, the term institution can have many meanings.

In one sense the idea of using the core or some other solution from cooperative game theory is a major step forward, from some imaginary mechanism in which people somehow send signals and receive messages and these are adjusted by some central mechanism until equilibrium is reached. The problem with the mechanism design approach is that the mechanisms do not emerge naturally from the interaction of agents but provide a carefully constructed framework within which the participants have to work. Whereas it seems to me that Mittermaier seems to suggest a process rather like the Iowa caucuses. But once again the rules have to be specified at some point though one could think of an iterative process of negotiation. But, to come back to the basic point, I see Mittermaier's approach as a significant step in incorporating the links that exist between individuals into the process of collective decision-making.

## 9. An alternative route

Having taken a long detour down one of the interesting paths that Mittermaier hit upon, I would like to make a quick reference to an idea that, I think, would have pleased him. When Werner Hildenbrand became disillusioned with the road that General Equilibrium had taken he basically abandoned the idea of using individual optimization as a basis for economic theory. He argued in his book *Market Demand* (Hildenbrand, 1994) that one could show that well-known relations in economics, often referred to as 'laws', could be derived from the choices that people actually made without specifying how or why they had made those choices. He did this for the 'Law of Demand' to which Mittermaier often referred. The idea is simple. In the simplest case, that of a single commodity, it simply says that when the price of a good decreases more of that good is purchased. This is easily generalized to the case of  $l$  goods and in that case says that the price vector moves in the opposite direction to the

goods vector. In the single good case we say that the demand curve is downward sloping. But what is chosen in aggregate need not be demand derived from individuals' preferences. We just need to know the quantities of goods that were purchased at different prices. However, to derive the aggregate law of demand we have to make some assumption about the nature of the choices. What Hildenbrand did was to assume that as prices rose the distribution of the amounts chosen by individuals became more spread out. Obviously this has to be correctly specified and tested empirically but from this assumption about the choices of all individuals one can prove the 'Aggregate Law of Demand' without having to reflect on the motives that people had for making those choices. It avoids so many of the restrictive assumptions we have made about people's preferences and is completely rigorous. Yet it gained little traction in the economics profession. I suspect that Mittermaier would have enjoyed thinking about it.

## 10. Conclusion

This book reveals a fascinating personality, widely read, influenced along his path by a variety of different people, various representatives of the Austrian school, but also taking a careful look at the formalists, many of whom are well described as 'dogmatic'. His strength was more logical and philosophical than mathematical, but this did not prevent him from pointing out some of the weaknesses in modern theory, which we too often skate over as quickly as possible. We have good reason to do so because otherwise we are likely to fall into rather cold water. I can only repeat that I regret not having had the opportunity to meet with Mittermaier and was struck by the many points that he focused on and which have given me pause for thought over time. I have probably spent too much time on the subjects that he dealt with which I am familiar with and may not have done him justice for the rest but even within that narrower field I learned a considerable amount from him.

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## Notes

- <sup>1</sup> Mittermaier discusses in this book the stand that Marshall took and Friedman's (over-)simplification of it. Marshall at one point argues that one may use mathematics to clarify one's statements but once one has reached a coherent conclusion one should throw the mathematics away. Not an attitude that is adopted by most authors in the leading economic journals.
- <sup>2</sup> Sarah Hart is professor of geometry at Gresham College in London where she holds the oldest mathematical chair in England, established in 1597, and is the first woman to do so.

- <sup>3</sup> The first theorem in this direction was proved by [Debreu and Scarf \(1963\)](#), although I have seen nothing in Mittermaier's work to suggest that he was aware of it and indeed his interest lay elsewhere.
- <sup>4</sup> Rob Axtell and Dooyne Farmer (2023) refer to the literature on coalition formation, and say that such models as have appeared in economics have been based on the idea that the members of a coalition have some characteristic in common, but do not go on to argue that such coalitions play an important part in macro-economics.

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