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Past-myopic economic agents

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Abstract

In this paper, the idea of myopic preference and myopic topology provided by Brown and Lewis is further explored. In this sense, new definitions of myopia are introduced for finite spaces. The main contribution of the work is the inclusion of the past in the models. We have defined the notions of past-myopic preference and topology for sequence spaces and n-dimensional spaces. Adding this new dimension makes it possible to work with decision spaces where the economic agent only has information about past events and when she has to choose accordingly to it, which is in line with the reality of certain economic situations, such as voting or finances. This approach generates a wide room for future research lines related to the idea of myopia. Based on this, it would allow to study in forthcoming research past-hyperopic topologies and preferences, and to interconnect different preferences, defined on the past and future models.

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1 Introduction

Brown and Lewis [1] defined economically and mathematically the concepts of *myopic preference* and *myopic topology* for the first time, where individuals have myopic tastes in an intertemporal context. Therefore, agents characterize their tastes by their preference relation, defined on their consumption space that is constituted by the set of bounded sequences ℓ_∞.

On that space, it is possible to define some topologies for which the preferences can be continuous and show a worthwhile property: impatience or intertemporal myopia. These are topologies for which every complete and continuous preference relation shows that present consumption is preferred to future consumption and that the taste for future consumption diminishes as time elapses [1].

The myopic behavior is not unique to consumption models. It can also be found in other decision-making spaces, as income models or intergenerational models [2].

However, sometimes the economic agent does not have information about the future outcomes in her decision set, and she only knows about what happened in the past, so she makes her decisions based on that information. This makes sense in cases where there is some predictability, i.e. there is a close relationship between what happened in the past and what will happen in the future, or some sort of causality.

In this way, incorporating remote past information into social choice models may provide valuable insights. The historical perspective allows an economic agent to anticipate future scenarios more accurately and identify patterns and trends. Besides, knowing how similar situations have been handled allows her to learn from successes and failures and avoid repeating past mistakes.

Thus, the decision set is constituted by sequences that contain past information and the agent decides, for each pair of alternatives, which of them she prefers, defining her preference relation.

Nonetheless, when we study past information, a phenomenon similar to myopia may occur: the further back in time a fact is found, the easier it is for the individual to forget or to ignore it when deciding between alternatives. This behavior can be encountered, for example, when voting or in the financial field. We could name it forgetfulness, but because of the parallelism, we will call it *past-myopia*.

2 Definitions related to future myopia

2.1 Preliminaries

First, we introduce some basic definitions:

Definition 2.1. A *total preorder* or a *preference* $\precsim$ on X is a binary relation on X which is transitive and complete.

Definition 2.2. Given a nonempty set X, a topology τ and a total preorder $\precsim$ defined on X, the preorder is said to be *τ-continuous* (and the topology τ is said to *natural as regards* $\precsim$) if for every $x \in X$ the so-called *strict contour sets* associated to x, namely $L(x) = \{y \in X : y \prec x\}$ and $U(x) = \{t \in X : x \prec t\}$ are both τ-open.

2.2 Myopia on sequence spaces ℓ_∞

In their work, Brown and Lewis [1] proposed the space of bounded sequences

$$\ell_\infty = \{(a_n)_{n=0,1,2,\ldots} : \sup_n |a_n| < k\}$$

for some constant $k > 0$, as the decision space. They referred to a set of infinite consumption bundles on which the economic agent set her preference relation $\precsim$.

The authors proposed the following definitions of *myopic preference* and *myopic topology*.

Definition 2.3. (Brown and Lewis [1]) A preference relation on ℓ_∞ is said to be *strongly myopic* if for all $\bar{x}, \bar{y}, \bar{z} \in \ell_\infty$, if $\bar{x}$ is preferred to $\bar{y}$ then $\bar{x}$ is also preferred to $\bar{y} + \hat{z}_n$ for all sufficiently large n, where $\hat{z}_n$ is a "tail" of $\bar{z}$, that is (i.e.), $\hat{z}_n(i) = 0$ for $1 \leq i \leq n$ and $\hat{z}_n(i) = \bar{z}(i)$ for $i > n$. Moreover, if for every i we have that $\bar{z}(i) = c$, where c is a constant, then the preference is called *weakly myopic*.

Example 2.4. Suppose that on ℓ_∞ we define a preference $\precsim$ as follows: We declare that $(a_n)_{n=0,1,2,\ldots} \prec (b_n)_{n=0,1,2,\ldots}$ if $a_0 < b_0$ or else $a_0 = b_0$; $a_1 < b_1$. In that case, and following Definition 2.3 just for $n = 2$ the tails $\bar{z}_n$ do not affect to the preference, which is indeed strongly myopic.

Definition 2.5. (Brown and Lewis [1]) A topology, τ, on ℓ_∞ is said to be strongly (resp. weakly) myopic if every complete preference relation which is τ-continuous is strongly (resp. weakly) myopic.

Example 2.6. As already said in [1], the product topology on ℓ_∞ is strongly myopic. A subbasis for that topology is the family $\Pi_{n\in\mathbb{N}} X_n$ such that, for any $n \in \mathbb{N}$, X_n is an open subset of the usual topology of the real line $\mathbb{R}$, and in addition $X_k = \mathbb{R}$ for every $k \in \mathbb{N} \setminus F$, where F is a finite subset of indices.

The definitions model the behavior of an economic agent who is indifferent to changes from a certain point on: the least preferred alternative can vary as much as we want from that moment on, but even doing so, the preference between those two alternatives is kept.

2.3 Myopia on finite models

In many economic contexts, we may think of an individual who would only consider a *finite* number of periods of time (for example, due to her life expectancy).

Therefore, the mathematical model here would consist of vectors in $\mathbb{R}^n$ of the type $(x_0, x_2, \ldots, x_T)$ where, for instance, x_i stands for the benefit (or loss) that an individual has got in the i-th period of time.

Let us suppose that here T stands for the maximum of the possible number of years of life of a person (say, e.g., 130). Once again, an individual can think that "once I have lived, say, 95 years, nothing will be of real importance to me, because I would not be able to function correctly due to my age and very likely physical and mental deterioration". Therefore, she would have a "sort of myopia" when comparing vectors $(x_1, x_2, \ldots, x_{130})$, in which the "tail" $(x_{95}, \ldots, x_{130})$ could be irrelevant, so-to-say, concerning the preference that such individual may have.

In this context, an idea of myopia can be introduced:

Definition 2.7. A preference relation on $\mathbb{R}^n$ is said to be *strongly myopic* if there exists $k < n$ such that for all $\bar{x}, \bar{y}, \bar{z} \in \mathbb{R}^n$, it holds true that if $\bar{x}$ is preferred to $\bar{y}$ then $\bar{x}$ is also preferred to $\bar{y} + \hat{z}_k$, where $\hat{z}_k$ is the k-th "tail" of $\bar{z}$, that is (i.e.), $\hat{z}_k(i) = 0$ for $0 \leq i \leq k$ and $\hat{z}_k(i) = \bar{z}(i)$ for $k < i \leq n$. In addition, if for every i we have that $\bar{z}(i) = c$, where c is a constant, then the preference is called *weakly myopic.*

Example 2.8. Analogously to Example 2.4 above, given $\bar{a} = (a_0, a_1, \ldots, a_n)$; $\bar{b} = (b_0, b_1, \ldots, b_n)$ we declare $\bar{a} \prec \bar{b}$ if $a_0 < b_0$ or else $a_0 = b_0$; $a_1 < b_1$. The corresponding preference $\precsim$ is strongly myopic.

Associated to Definition 2.7, we introduce a new definition in terms of topologies that could be defined on $\mathbb{R}^n$:

Definition 2.9. A topology τ on $\mathbb{R}^n$ is said to be *strongly myopic* (resp. *weakly myopic*) whenever every complete preference relation on $\mathbb{R}^n$ which is τ-continuous is strongly myopic (resp. weakly myopic).

3 New definitions of myopia related to past events

Regardless of the context of the model, the economic interpretation of a preference over streams that gather information about the past is subtly different from that found in the future models traditionally used.

When we define a preference relation over past streams, we do not evaluate past trajectories because we want to choose one of them; we do so because of their potential connection to the future.

In this way, the economic agent is defining an ordering on the set of streams that contains the necessary information about the past for building her expectations about the future.

Therefore, we no longer ask the economic agent to choose the outcomes of one alternative over another. Instead, we ask her to make a comparison between the trajectories that will help her to build her future expectations.

As said before, we find a problem analogous to the myopic one defined for the future case: when the agent has to evaluate past trajectories, bounded rationality, and recency bias make individuals unable to analyze infinite information [4]. In this sense, they tend to focus their analysis on a limited number of periods, which reminds us of the short-termism or impatient behavior we studied above. This "forgetfulness" is the phenomenon we will study in the context of an economic agent's preferences over past trajectories.

3.1 Sequence spaces

Considering *sequence spaces*, in the spirit of Brown and Lewis ([1]) but now looking backward, into the past, we may similarly use the space of bounded sequences $\ell_\infty(-\mathbb{N}) = \{(a_i)_{i=0,-1,-2,\ldots} : \sup_i |a_i| < k\}$ for some constant $k > 0$. Observe that now we the subindex i refers to something that occurred i periods ago in the past.

We introduce now the following definition relative to past-myopia:

Definition 3.1. A preference relation on $\ell_\infty(-\mathbb{N})$ is called *strongly past-myopic* if, for all $\bar{x}, \bar{y}, \bar{z} \in \ell_\infty(-\mathbb{N})$, it holds true that if $\bar{x}$ is preferred to $\bar{y}$ then $\bar{x}$ is also preferred to $\bar{y} + \hat{z}_i$ for all sufficiently large i, where $\hat{z}_i$ is a "tail to the past" of $\bar{z}$, that is, $\hat{z}_i(j) = 0$ for $0 \geq j \geq i$ and $\hat{z}_i(j) = \bar{z}(j)$ for $i > j$. In addition, if for every j we have that $\bar{z}(j) = c$, where c is a constant, then the preference is called *weakly past-myopic*.

Remark 3.2. Mathematically, this is analogous to Definition 2.3. Now the subindices i refer to the past whilst in Definition 2.3 the subindices n referred to the future.

Example 3.3. Again in the spirit of Example 2.4, if for any given $\bar{a} = (a_i)_{i=0,-1,-2,\ldots}$ and $\bar{b} = (b_i)_{i=0,-1,-2,\ldots}$ in $\ell_\infty(-\mathbb{N})$ we declare $\bar{a} \prec \bar{b}$ if $a_0 < b_0$ or else $a_0 = b_0$; $a_{-1} < b_{-1}$, the corresponding preference $\precsim$ is strongly past-myopic.

The definitions of myopic topologies also mimic those introduced in [1]:

Definition 3.4. A topology τ on $\ell_\infty(-\mathbb{N})$ is *strongly (respectively, weakly) past-myopic* whenever every complete preference relation on $\ell_\infty(-\mathbb{N})$ which is τ-continuous is strongly (respectively, weakly) past-myopic in the sense of Definition 3.1.

Example 3.5. The product topology on $\ell_\infty(-\mathbb{N})$ is strongly past-myopic.

Example 3.6. Suppose an investor is considering buying stocks of different financial institutions. She has information about their daily performance, so her decision space is $\ell_\infty(-\mathbb{N})$, where each sequence $\bar{x} = (x_0, x_{-1}, x_{-2}, \ldots)$ is the historical performance of the stock, and x_{-i} represents the performance i days ago. The past myopic behavior could make the investor look only at the bank's recent data, without considering the historical data on the company's stock performance, or other past factors that might affect the stock's current price. Ignoring the past on her preference could lead the investor to make risky decisions due to a lack of thorough analysis of past stock performance.

3.2 Finite past-myopia

To formalize a suitable definition of *past-myopia in the finite case*, we will consider a number, say m, that corresponds to our –finite– time horizon with respect to the past, so that from a moment $n = 0$, we consider the periods -1 (i.e.: one period before), -2, and so on till $-m$. In this setting, we will define our preferences on $\mathbb{R}^F$, with $F = \{-m, -m+1, \ldots, -2, -1, 0\}$. Here $\mathbb{R}^F = \{(x_{-m}, x_{-m+1}, \ldots, x_{-2}, x_{-1}, x_0) : x_i \in \mathbb{R} \ \ (-m \leq i \leq 0)\}$, and x_i could be interpreted as, say, the gross profit (or loss) that a person had i periods before the origin of time.

Definition 3.7. A preference relation on $\mathbb{R}^F$ is said to be *strongly past-myopic* provided that there exists k with $-m < k < 0$ such that for all $\bar{x}, \bar{y}, \bar{z} \in \mathbb{R}^F$, it holds true that if $\bar{x}$ is preferred to $\bar{y}$ then $\bar{x}$ is also preferred to $\bar{y} + \hat{z}_k$, where $\hat{z}_k$ is the k-th "backwards tail" of $\bar{z}$, that is (i.e.), $\hat{z}_k(i) = 0$ for $k \leq i \leq 0$ and $\hat{c}_k(i) = \bar{z}(i)$ for $i \in \{-m, \ldots, k-1\}$. Moreover, if for every i we have that $\bar{z}(i) = c$, where c is a constant, then the preference is called *weakly myopic*.

Definition 3.8. A topology τ on $\mathbb{R}^F$ is called *strongly* (respectively, *weakly*) *past-myopic* provided that every complete preference relation on $\mathbb{R}^F$ which is τ-continuous is strongly (respectively, weakly) past-myopic in the sense of Definition 3.7.

Example 3.9. Consider the case of a voter facing a presidential election. The most important thing to the voter is the integrity of the potential president. The voter knows the political trajectory of the candidates in the last four-year legislature and is able to evaluate, on a monthly basis, the degree of coherence between what they defended in their electoral program and what they have done (let us say, for example, that the agent evaluates between 0 and 1, where 0 is a policy contrary to what was defended and 1 is that what was defended in the electoral program is fulfilled). The voter faces a decision set formed by vectors with 48 components. However, the past-myopia may lead the voter to consider only a limited number of periods when evaluating the trajectories, which, according to some studies [5], is about two years.

4 Discussion and a suggestion for further research

4.1 A brief discussion

The economic literature has based its research on the study of an agent's behavior with respect to future decisions. However, an analysis of behavior and decisions based on the past directly influences this analysis and has not been taken into account.

Behavioral economics [4] shows the existence of behavior similar to myopia, but backward on the past, where the economic agent considers only a limited number of periods. For this reason, we model this scenario and provide a topological basis from which to explore these and other new concepts.

The inclusion of the past in current models may lead to a reconsideration of the behavioral patterns of an economic agent in its future decision-making.

This new vision makes it possible to develop future research lines in which these past and future concepts can be related.

Let us consider now an illustrative example –in this case not involving preferences, but just data– about how past events could be used to forecast future ones.

Example 4.1. Several mathematical models encountered in Economics, as, for instance the cobweb or the adaptive expectations model lean on a mathematical concept known as *finite differences*. Basically, if we have a sequence of real numbers $(x_n)_{n\in\mathbb{N}}$ an *equation in finite differences, of order* k, if a rule that relates the value of a general term x_{n+k} in the sequence with its k previous terms $x_n, x_{n+1}, \ldots, x_{n+k-1}$. The typical case is the existence of a real-valued function F depending on k real variables such that $x_{n+k} = F(x_n, x_{n+1}, \ldots, x_{n+k-1})$ is assumed to hold true for every $n \in \mathbb{N}$. We may immediately notice that, if we know the values of the former k terms $x_0, x_1, \ldots, x_{k-1}$ we can recurrently obtain the term of any term x_n of the sequence. A typical example here is the Fibonacci sequence $1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, \ldots$ in which the rule is $x_{n+2} = x_n + x_{n+1}$ and $x_0 = x_1 = 1$.

Suppose now, for instance, that a certain firm would like to forecast the benefit or loss it will have from the current year on, based on the profits or losses had in previous years. If, for instance it has information about the past three years so that the corresponding benefits b_{-3}, b_{-2}, b_{-1} have been, respectively, $1, 2, 3$ million dollars, perhaps the firm can think of the validity of the rule $b_{n+2} = b_n + b_{n+1}$ for $n > -3$, so that, for instance, $b_0 = 5$, $b_1 = 8$ and so on. However, with more information about the past, the prevision could be totally different. For instance, if we know that $b_{-4} = 6$, $b_{-3} = 1$, $b_{-2} = 2$, $b_{-3} = 3$, the above rule $b_{n+2} = b_n + b_{n+1}$, but for $n > -4$ does not hold. Therefore, now we perhaps could think of the rule $b_{n+3} = b_n - b_{n+1} - b_{n+2}$ for $n > -4$, which leads to a totally different forecasting, namely $b_0 = -4$, $b_1 = 3$, etc.

4.2 Ideas for further research: past-hyperopic topologies

In the opposite way to the case of myopia, an economic agent can concentrate her attention on what will happen in the long-term future, disregarding the first periods. This idea was developed by Monteiro et al. [3] who introduced the concept of *hyperopic preferences.*

Similarly, we can adapt this definition to their backward-looking-at version. This new concept called *past-hyperopic preferences*, will describe the behavior of an economic agent who, when she has available information about past trajectories, focuses on what happened in the distant past, ignoring what has happened in recent periods.

As we have done in the case of myopia, it could be interesting to model the preferences of economic agents when they do not consider their recent past, following the idea of hyperopic preference and topology of Monteiro et al. [3], but defined backward.

These authors model the behavior of those individuals who do not consider the recent future when comparing alternatives and, indeed, focus on what happens in the long-term future. They named this behavior as *hyperopic.*

Monteiro el al. [3] defined the concept of hyperopic preference in this way:

Definition 4.2. (Monteiro et al. [3])
Let $\precsim$ be a preference relation on ℓ_∞. Then, $\precsim$ is *hyperopic* if for all $\bar{x}, \bar{y}, \bar{z} \in \ell_\infty$, if $\bar{x}$ is preferred to $\bar{y}$ then $\bar{x}$ is also preferred to $\bar{y} + \hat{z}_n$, where $\hat{z}_n$ is the initial cutoff of $\bar{z}$, that is (i.e.), $\hat{z}_n(i) = \bar{z}(i)$ for $1 \leq i \leq n$ and $\hat{z}_n(i) = 0$ for $i > n$.

The definition of hyperopic preference can also be considered in $\mathbb{R}^n$:

Definition 4.3. A preference relation on $\mathbb{R}^n$ is said to be *hyperopic* if there exists $k < n$ such that for all $\bar{x}, \bar{y}, \bar{z} \in \mathbb{R}^n$, it holds true that if $\bar{x}$ is preferred to $\bar{y}$ then $\bar{x}$ is also preferred to $\bar{y} + \hat{z}_k$, where $\hat{z}_k$ is the k-th "initial cutoff" of $\bar{z}$, that is (i.e.), $\hat{z}_k(i) = \bar{z}(i)$ for $0 \leq i \leq k$ and $\hat{z}_k(i) = 0$ for $k < i \leq n$.

Example 4.4. We can understand as hyperopic preferences on finite spaces those of a young person when she has to choose between different job offers. Let us suppose that a person is 20 years old and knows that she will work at least until the age of 70. It is plausible that the young person, when deciding on a career path, will not take into account what happens in the first few years - say, the first 5 years - since those years have a formative purpose so that what is important for her is what happens in the long term when her career is stabilized, from the age of 25 to 70.

The phenomenon of past-hyperopia occurs in the behavior of those agents in which the security provided by familiarity dominates. There are many cases in which tradition, what is known, what has been happening for a long time and is already established in everyday life, gains weight over what is new, what has just arrived. This is where hyperopia consolidates its meaning and scope. Therefore, it seems reasonable to think that some people put the oldest first, ignoring what has happened in the recent past when choosing between alternatives.

Just as a sample, we introduce here a definition for *past hyperopic preferences.*

Definition 4.5. A preference relation on $\ell_\infty(-\mathbb{N})$ is said to be *past-hyperopic* if, for all $\bar{x}, \bar{y}, \bar{z} \in \ell_\infty(-\mathbb{N})$, it holds true that if $\bar{x}$ is preferred to $\bar{y}$ then $\bar{x}$ is also preferred to $\bar{y} + \hat{z}_n$ for all sufficiently large n, where $\hat{z}_n$ is the "initial cutoff of the past" of $\bar{z}$, that is (i.e.), $\hat{z}_n(i) = \bar{z}(i)$ for $1 \leq i \leq n$ and $\hat{z}_n(i) = 0$ for $i > n$.

Example 4.6. Assume a manager who makes investment decisions related to technological innovations. The manager has information on the performance of companies in the industry, which depends essentially on the technology. There is an established technology in the industry, which is the one adopted by most companies, but in recent years an innovative technology has been introduced that generates higher profits than the traditional one. However, this technology is still under development, and the evidence of its implementation dates back to the last few years.

When ordering past business trajectories, the manager may ignore the last few years of company performance, prioritizing the stability seen in the long term over a possible one-off improvement in profit due to the implementation of this new technology. In this case, the manager's preferences would be past-hyperopic. This behavior may inhibit the adoption of recent technologies that are more cutting-edge, which will affect future productivity, but, at the same time, reduce the risk of the investment, because it assures a level of productivity.

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Conflict of interest

The authors have no conflicts of interest to declare. All co-authors have revised, and agree with, the contents of the paper and there is no financial interest to report. We certify that this is original work, and it is not under review at any other publication.

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