Pilot-Wave Theory and Financial Option Pricing

Emmanuel Haven

This paper tries to argue why pilot-wave theory could be of use in financial economics. We introduce the notion of information wave. We consider a stochastic guidance equation and part of the drift term of that equation makes reference to the phase of the wave. In order to embed information in financial option pricing we could use such a drift. We also briefly argue how we could embed information in the pricing kernel of the option price.

KEY WORDS: pilot-wave; Brownian motion; option pricing.

PACS: 03; 89.65.Gh.

1. INTRODUCTION

Asset prices such as stock prices are influenced by macroeconomic and psychological factors. Macroeconomic factors (see for instance Ross, 1976) have received ample attention in the economics and financial literature. On the issue of using psychological factors in explaining financial phenomena, we are in a more difficult situation. Important attempts have been made (Shiller, 2000) but the area is still welcoming new models.

In this paper we apply pilot-wave theory as developed by David Bohm (1952), in the theory of financial option pricing. A financial option is a contract where the buyer has the right to buy (or the right to sell) an underlying asset (such as a stock) at a certain price at a given date. An important question is to know what the price of such contracts should be. Option pricing theory has been developed by Black and Scholes (1973) and the third section of this paper provides for more details on this theory. In all of this theory, no mention is made of the role “information” may play in the price formation of such contracts (but see Chang and Chang, 1996, for some extensions). Indeed only macroeconomic factors are taken into account to explain the price trajectory. Such macroeconomic factors, can be explained in a physics environment, by a classical potential. However, psychological factors,

1 Department of AFM, University of Essex, Wivenhoe Park, CO43SQ, Colchester, United Kingdom; e-mail: ehaven@essex.ac.uk.
which are also of importance in price formation, could be taken into account by a quantum potential representing an information potential. Although there is more often than not a strong connection between macroeconomic factors and psychological factors, this connection sometimes can be quite weak. This can be seen in the case of so called price bubbles where the prices of certain assets are in fact “hyped up” by massive fear (or on the contrary massive exuberance) amongst investors. The key ingredient in Bohmian mechanics is the pilot-wave and it is this wave which induces the quantum potential. Furthermore, the form (but not the intensity) of this wave is what counts. In Bohm and Hiley (1993) the pilot-wave is exemplified as a radio wave which steers a ship on automatic pilot. It is the form of that radio wave which counts, not its intensity. In Bohm and Hiley (1993) “information” is defined in a particular way. The notion of “active information,” is information which has relevance to the movement of an electron itself and this notion of information has much less to do with, in the words of Bohm and Hiley (1993), “a quantitative measure of information that represents the way in which the state of a system is uncertain to us.” The use of such “active information” has already been applied in other fields, notably by Khrennikov (2000) in his work on pilot-wave theory in cognitive-psychology models. We believe that this notion of “active information” is very much the type of information we need to better explain price behavior. We consider “active information” in our financial option pricing context as psychological information which can drive prices.

In this paper we focus on how pilot-wave theory could be used so as to embed information in financial option pricing. The paper is structured as follows. In the next section, we define why pilot-wave theory could be useful in financial economics. In the section following, we consider two brief applications of the pilot-wave theory in the financial theory of option pricing: (1) we consider the price of an option contract when information (of the pilot-wave) is embedded in the option contract; (2) we consider the price of the option when the pricing kernel is modified.

2. THE INFORMATION PILOT-WAVE: DEFINITION AND POSSIBLE CONNECTIONS WITH FINANCIAL ECONOMICS

Khrennikov (1999, 2003) provides for some good reasons why pilot-wave theory could be used in economics. The pilot-wave is seen as a wave of information. As in Khrennikov (2003), we have \( n \) traders and there is a configuration space, \( S = \mathbb{R}^n \) of prices, \( s = (s_1, s_2, \ldots, s_n) \) where the price \( s_i \) is the price proposed by trader \( i \). There is a price trajectory \( s_i = (s_1(t), s_2(t), \ldots, s_n(t)) \). From Bohmian mechanics (Bohm, 1952) we know then that

\[
\frac{ds_i}{dt} = v^\psi(s_i),
\]