SSM
Scuola Superiore Meridionale

# MERC PhD Project Proposal 2022/2023

## Title of the research project:

Stochastic models for environmental investment decisions

## Keywords (up to five)

Stochastic differential equations, stochastic control, stochastic games, green finance

## Supervisors (at least two from two different areas):

*Supervisor 1 (name, contact details, homepage, area of expertise)*
*Tiziano De Angelis*
*https://sites.google.com/site/tizianodeangelis*

*Supervisor 2 (name, contact details, homepage, area of expertise)*

## Project description (max 5000 characters)

*Please include a description of the work to be carried out. State of the art, key research questions and project objectives, workplan and the methodological and application aspects of the project.*

*The overarching goal of the project is to determine whether, and by how much, investors with environmental preferences are able to accelerate a green transition of the productive sector, by suitable portfolio allocation decisions. The productive sector of the economy is described by N-firms that produce various goods. Firms raise funds by issuing stocks and equities which are traded on the market, where various types of investors operate (say M investors for simplicity). The interaction between firms and investors can be described by stochastic games in which general equilibrium criteria must be developed (Duffie, D., 2010. Dynamic asset pricing theory. Princeton University Press).*

*Firms whose stocks are in high demand see their stock prices rise so that their access to capital is easier. On the contrary, firms whose stocks are not very popular need to lower their stock price and it is harder for them to raise the funds needed to run the business. Stock prices are formed by demand and offer and, in particular, by the investors' portfolio allocation decisions. In the classical economic and financial literature, investors are interested in maximizing their wealth and that is the only criterion driving their portfolio allocation. In this framework investors must take into account financial risks deriving from changing environmental regulations (so-called transition risks). However, the evaluation of such risks is highly subjective and a solid mathematical model must include investors' beliefs/perception of potential risks as part of the input parameters (De Angelis, T., Tankov P., Zerbib, O.D. (2022) Climate impact investing. To appear in Management Science). A further complication arises if we assume that not only investors are wealth maximisers but they also have precise environmental preferences (i.e., some investors are not willing to invest in highly polluting firms). In particular, a question that we want to address in this project is if and by how much the environmental preferences (and beliefs) of a pool of investors can push firms towards a quicker transition to greener production practices.*

*At the technical level, students working on this project will formulate stochastic games modelling the situations described above. These models will range from the micro-scale to the macro-scale. At the micro-scale, the student will consider (N+M)-player stochastic games featuring controls and stopping times. The aim is to devise general results on existence of equilibria and then implement those results via efficient numerical algorithms. At the macro-scale, the student will consider more abstract models in which investors and firms are modelled in a stylized fashion by, for example, aggregating them into a single representative firm and a single representative investor. This approach should lead to closed-form solutions of the games and allow in-depth qualitative analysis of the models. The project naturally extends towards the theory of Mean Field Games when letting (N+M) tend to infinity (Carmona, R. and Delarue, F., 2018. Probabilistic Theory of Mean Field Games with Applications I-II. Springer Nature). In MFGs a representative player interacts with the distribution of the other players and the problem becomes one of stochastic control with an additional consistency condition (i.e., the optimally controlled state dynamics of the representative player must have the same distribution as the one of the other players). Further extensions and ramification of the project may include, for example, the introduction of a social planner and its impact on the market mechanisms and on the speed of the green transition.*

## Relevance to the MERC PhD Program (max 2000 characters)

*Briefly describe how this project fits within the scope of the MERC PhD program describing its interdisciplinary aspects, relevance in application and beneficiaries.*

The project fits within the Risk area of MERC. Environmental transition risk is indeed a major challenge for our economies and increasing efforts are being devoted to the study of its mitigation. The methods and expected outcomes of the project straddle various research areas within MERC, from stochastic control to multi-agent models, passing through numerical methods for large interacting populations.

## Key references


Carmona, R. and Delarue, F., 2018. Probabilistic Theory of Mean Field Games with Applications I-II. Springer Nature

De Angelis, T., Tankov P., Zerbib, O.D. (2022) Climate impact investing. To appear in Management Science

Duffie, D., 2010. Dynamic asset pricing theory. Princeton University Press

Karatzas, I. and Shreve, S., 2012. Brownian motion and stochastic calculus (Vol. 113). Springer Science & Business Media.


## Joint supervision arrangements

*Describe joint supervision arrangements, e.g. weekly/monthly meetings with one or both supervisors, how will the joint supervision be split etc.*

*Weekly meetings with T. De Angelis either online or in presence. Monthly meetings with both supervisors.*

## Location and length of the study period abroad (min 12 months)

*Give details of the foreign research institution where the student will be host together with the full name and contacts of the foreign host. Please indicate if the foreign institution has already agreed to host the student and when the student is expected to travel abroad.*

*Possible hosts for the period abroad are*
*Prof. Peter Tankov, ENSAE Paris*
*Prof. René Aid, Paris Dauphine*

*I have ongoing collaborations with both Tankov and Aid and they are both available to host PhD students from MERC*

## Any other useful information

*E.g. involvement of stakeholders, industrial partners, other research institutions etc, funded research projects related to the proposed activity etc.*

*Caio Cesar Graciani, who is postdoc at SSM is working on closely related topics, so the PhD student would also benefit from regular interactions with Caio.*

***Please return this form via email by no later than 24th February 2023***