SHORT TERM SCIENTIFIC MISSION (STSM)
SCIENTIFIC REPORT

This report is submitted for approval by the STSM applicant to the STSM coordinator

Action number: CA15210
STSM title: HLA-testing and re-optimisation of transnational KEPs
STSM start and end date: 16/09/2019 to 17/01/2020
Grantee name: Márton Gyetvai

PURPOSE OF THE STSM:

From the Hungarian side, the visit involved Márton Gyetvai, a PhD student at the Corvinus University of Budapest and junior research fellow of the Mechanism design group of KRTK. Ana Viana and her OR group were the hosts at INESC TEC. The collaboration started with a one-week visit by Péter Biró (senior researcher at the Hungarian Academy of Sciences, KRTK), Márton Gyetvai and Réka Kis-Benedek (student in mathematical economics at the Corvinus University of Budapest) in February 2018. Ana Viana and her colleagues then visited the Budapest group in December 2018.
The purpose of this extended short term scientific mission was to continue this collaboration with a possibility of extension. We planned to investigate some HLA lab testing policies when multiple lab centres are operating the Kidney Exchange Programme.

DESCRIPTION OF WORK CARRIED OUT DURING THE STSMS

In the first part of the STSM, we researched the fairness of the multinational KEPs. In our STSM to Porto in February of 2018, the research group of Porto presented their results about the fairness of the multinational KEPs (X. Klimentova, A. Viana, J.P. Pedroso and N. Santos. Fairness models for multi-agent kidney exchange programmes. *Submitted to Omega: The International Journal of Management Science*, 2019).
In the context of the multinational KEPs, the payoffs of the countries are the number of transplants they can make in the collaboration. In the fair model, the objective is to find a payoff which is closest to the contribution of each player.
In the current STSM, we investigated this topic further by comparing the fair value that was used in the article to calculate the payoffs with the Shapley-value (L. S. Shapley (1953). A Value for n-person Games. *In Kuhn, H. W.; Tucker, A. W. (eds.). Contributions to the Theory of Games. Annals of Mathematical Studies. 28. Princeton University Press.* pp. 307–317). The Shapley-value is a well-known value from the field of cooperative Game theory. This value is the only one, that holds 4 axioms that are important to a game to be fair for each player. We compared the two values with multiperiod simulations. To make these simulations, we extended the Simulator, developed by the Porto research group earlier.

In the other part of the STSM, we focused on the virtual crossmatch tests of a multi-centre KEP. The main aspect of this research was to investigate the effect on the different measurement accuracy of centres in the HLA-testing.

We investigated the case when one of the participating centres has such a good measuring accuracy, that can predict with 100% which transplantation would fail and which would not. However, the other centres only know it with usually less probability.

We investigated the effect with the comparison to the case when all of the centres have less effective HLA-testing. We made the comparison via simulations. We used the Porto Simulator for multi-period results. Also, we determined the effect on every recipient-donor pairs with Monte Carlo simulation.

Furthermore, during this STSM, I also contributed to the handbook 2 of working group 3. I participated in editing the overview of existing models in the literature of mKEPs.

DESCRIPTION OF THE MAIN RESULTS OBTAINED

About the fairness model, we run several scenarios of mKEP.
We found that the value used in the article has very similar results to the Shapley value, in sense of the number of transplants. However, the Shapley-value had a smaller deviation of the fair values.
The smaller deviation is important because it means the participating country would get a closer number of transplant to her fair number. It also means that with the Shapley value there is less chance that one of the participants would get a very unfair result.

We tested several scenarios with the multiperiod simulator.
When the sizes of the pools of the countries differed, the application of the fair model was more important. When a country collaborates with a smaller pooled country, the smaller sized would gain more from this collaboration. Hence the application of the fairness model would increase the gain of the larger country, to make it more beneficial to her. Besides, the participants with non-directed donors may get harmed without the fairness model.

In the research of HLA-testing, we found that better accuracy would increase the number of transplants. However, if there are two centres collaborating and one has better accuracy, then the other may lose transplants when they collaborate.
Also, the probability of successful transplant would increase for the patient of the improving centre. However, the patients from the other centre would get a worse result. Besides the increase in the chances for selection would affect more the pairs from the improving centre.

FUTURE COLLABORATIONS (if applicable)

We will proceed with work and aim at publishing the results obtained by the two research topics. For the research about the fair mKEPs, we invited Professor David Manlove and his Post-doc researcher William Pettersson from the University of Glasgow and Péter Biró from the KRTK to contribute.