To whom it may concern:

External report on "511140-TEMPUS-1-2010-1-RS-TEMPUS-JPCR: Master program in Applied Statistics"

The main objective of this project was to develop and implement a master curriculum in applied statistics in line with existing European study programs and according to Bologna requirements. As I will explain in this report, I consider that this objective has been well met given that the proposed program is well-prepared, feasible and interesting.

Nowadays, it is widely recognized that the use of statistical tools is needed in modern world. Moreover, the ability to understand, process, and, extract value from available data will become even more important in the next decades due to the increased computer power that has led to the creation of complex/large databases in many fields. This challenge will require many professionals with enough statistical knowledge and skills to extract the valuable information hidden in such vast data sources. Applied Statistics programmes, like the one developed through this TEMPUS project, must prepare the students to be the well-trained statisticians which society now requires. It is clear that an inefficient or erroneous treatment of all available data sources would lead to severe consequences in any modern country. Finally, note also that present research standards demand high quality data analyses that are not straightforward for everyone. Thus, there is a clear job opportunity for people who master this applied statistical background through the collaboration with other people in research/industry.

The proposed organization of the Master in Applied Statistics is very attractive. It first offers an initial course where all the general statistical principles are presented. Also, some fundamental/basic courses are offered in such a way that they prepare the students for the different modules (Economy, Engineering, Medicine and Social Sciences) that will be taken the following year. This is also very important due to very different students' origins and backgrounds. Therefore, an overview of the basic principles of the disciplines considered within the specialization modules is a sensible idea. This would help to equalize the initial knowledge of all students.

Moreover, the organization of the second year into four modules (Economy, Engineering, Medicine and Social Sciences) is also a good idea. These are the four main profiles that society requires for a Statistician, and I agree that a proper specialization in one of these

areas is appropriate. Although the basic statistical principles (presented in the first year) are common to all four modules, each of them also requires some very specific statistical tools. It is very important to speak the "same scientific language" as the researchers with whom we are going to work. From my personal experience, this is something that traditional studies often neglect. These modules prepare the student to speak these particular languages, to use the most modern statistical tools in these fields and to ease the integration process in their future jobs.

Another valuable feature is the clear focus put on practical aspects of the proposed Applied Statistics Master programme. This particular choice, of course, implies the exclusion of some of the more theoretical, abstract or formal aspects of Statistics that are interesting by themselves but have very limited practical use in real applications. I think that the theoretical background that is required when enrolling in the program, together with the preparation from the first course, is enough to understand the statistical tools as more than a set of unexplained rules to be learnt by heart. Additional theoretical justifications can be specifically provided if needed when presenting the new statistical tools. This teaching approach enables students to solve real problems (by handling real-world data) as a direct way of mastering statistical techniques.

Focusing on the applied and realistic nature of the programme, the key role played by statistical computing techniques is a very important part of the proposed Master. The use of the computer allows for exploration and use of several modern techniques (many of them computer-intensive ones) not only by following theoretical arguments but also by seeing how these techniques actually solve complex problems in diverse fields of application. Note also that the computer will be the main working tool in the students' future jobs because this is clearly how Statistics is currently implemented in practice.

Related to the importance of computing in this Master programme, I would also like to acknowledge the relevance of the R programming environment. R is a powerful open-source statistical programming language. Apart from saving high licensing costs, it also enables the student to access to statistical software from home or wherever else necessary. R has recently exploded in popularity and functionality among the statistical community and so it allows for the implementation of the most recent statistical techniques. This does not mean that other commercial programs must be completely forgotten. As previously commented, it is important to speak the same language that the researchers with whom we are going to work. Therefore, it is important the students being able to apply other (statistical) packages or programing systems that are commonly used by other researchers in Economy, Engineering, Medicine and Social Sciences. These other specialized systems could be taught in the four elective modules

that the programme includes. Moreover, an short introduction to all of them is already given in the "Statistical Software" course.

Another interesting feature of this Applied Statistics Master programme is that is the result of a fruitful collaborative effort among different universities in Serbia, supervised by different European Union universities and by non-academic partners as the Republic Statistical Office of Serbia and the National Bank of Serbia. This has resulted in a comprehensive programme where several different points of view have been taken into account.

With respect to its comparison to other existing programmes, I think that the programme is comparable in coverage and quality to other high-quality programmes in other institutions of higher education. The design of the programme is coherent with the Bologna-system philosophy employed all over Europe which facilitates the mobility of students, teachers and researchers.

In summary, I judge that the proposed Master in Applied Statistics programme will effectively train experts who are able to use the most modern techniques in Statistics. This will allow them to provide valuable quantitative analyses and apply data-analytic tools to many interesting problems posed by society. Surely, the final design of this Master in Applied Statistics would have not been so appealing without the valuable funding support of this TEMPUS project. Finally, although this was not the main objective of the project, another important by-product is the establishment and reinforcement of (teaching and research) collaborations among the different partners in the project.

Some suggestions:

As I have commented, I consider that the proposed program is well-prepared, feasible and interesting. Therefore, I don't have any substantive complain concerning the program. My only suggestion is an invitation to think a bit more about whether it is possible to add or extend the presentation of certain topics in the Master programme. I'm not saying that the topics that will be listed below are necessarily more important than those already included in the programme. However, I would recommend taking them more into account in further revisions of the program due to their importance for a statistician. Of course, I recognize in advance that it is not an easy task due to obvious time constraints.

1) *Stochastic Processes:* This topic has often received a very formal and theoretical treatment that I'm not recommending. However, several applied approaches to this topic are

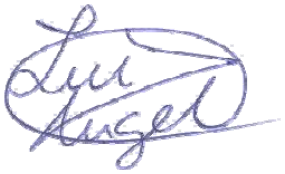
recently emerging. Thus, we can see how stochastic processes can be applied in an easy way when modelling stochastic systems and in data analysis.

2) *Operations Research:* This discipline is often related to Statistics since it traditionally includes interesting applications where ``randomness" appears (scheduling, queuing theory,…). Moreover, some data analysis techniques are frequently based on optimality criteria where Operations Research techniques turn out to be useful. Although I'm seeing that some electives courses are offered ("Data Envelopment Analysis" and "Operations Research"), I think that an obligatory basic course could be also interesting.

3) *Computing and Databases:* As I have already commented, the obligatory courses in the first course must be seen as an opportunity to equalize the initial knowledge of all students. This way, the "Statistical Software" course could be used to equalize the initial knowledge on Computing. For instance, it is very important to be able to access efficiently to data bases (SQL queries,..) in order to later use statistical procedures on the retrieved data. Therefore, although "general computer literacy" is requested for enrolling the Master, a basic course on "Computing" could be also useful. The trend to larger data sets ("Big Data Analytics") requires professionals with good knowledge on Statistics and also good Computing skills. This perhaps implies that the short introductions to programming in commercial statistical packages like SPSS, Statistica, SAS,… in the "Statistical Software" course must be deferred to (for instance) the four specific modules.

4) *Reliability:* I consider that "Reliability" should have more importance within the Engineering Module.

Done in Valladolid, June 14th, 2013



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