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On the dynamics of national scientific systems: a reply

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The comments of Everett (2011) and Light and Moody (2011) confirm our sense that, as a part of studying the dynamics of scientific change, we are tackling an interesting and important set of problems by using a wonderful data set. We appreciate their constructive critiques, especially their prompts to look more closely at the data we have. Their comments also make it clear that we are greatly indebted to the people at Institute of Information Science in Maribor (IZUM) for their maintenance of the Current Research Information System (SICRIS) and Cooperative Online Bibliometric and Services (COBISS) data archives. Without these data sets we could not study total disciplinary networks within the Slovene national science system. We are privileged in having access to these data. We agree with Everett (2011) about the value of comparing this national system with other such systems. However, we do not know of one and hope that our efforts could help promote the idea of creating comparable data sets in other nations. They may, indeed, exist and, if so, we would be more than willing to share ideas with researchers elsewhere regarding national scientific systems.

We agree also with Everett that attention to how data sets are created is merited, especially with regard to the many decisions that must be made in designing them. Some of these decisions are made explicitly while others are made implicitly. We know that some features of the results we report in our paper Kronegger et al. (2011), henceforth KFD, differ somewhat from those of both Newman (2004) and Moody (2004) because of the wider framework used by IZUM for including information. We think that our research program is enhanced by this expansive inclusion of more types of scientific productions. This is a particularly valuable

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feature of the data we use and we plan closer examinations of the different types of scientific productions and their roles in science. Even so, because of the historical importance of articles within science as a form of communication, we agree with Everett that it would be useful to give more attention to the nature of articles that are produced. His examples of differences between the research cultures of theoretical and empirical physicists and between pure and applied mathematical productions are compelling. The scientific productions in our data set are tagged with regard to content and we know the employment locations (universities and research institutes) of the scientists who are involved in coauthoring scientific output. In future work we will pursue a detailed examination of problems addressed in, and the content of, articles and their impact on collaboration. While we accept Everett's assessment that this could be seen as a distraction from the main findings, we think he is pointing us towards an important topic for study.

Everetts examples hint at collaborations between fragments of disciplines and parts of different disciplines. Light and Moody (2011) are more explicit about the problem of disciplinary boundaries for the study of science. Undoubtedly, they are correct in claiming that every analysis of science requires an imposition of boundaries. We note that KFD (Figure 4) provides some information about collaborations outside the research specialties—but this was secondary to the disciplinary results that we reported. We agree with Light and Moody that we benefitted from a design that avoids the problem of selecting a topic or database that imposes or infers disciplines. Light and Moody ask: What is lost in analyses that deploy a strict disciplinary boundary if increasing resources and attention are being spent on interdisciplinary disciplinary research? While it is true that there are increased resources for interdisciplinary work, it seems that disciplinary members still primarily mark their boundaries and turf. So there is much to be gained by studying disciplines. However, Light and Moody question is important and we think that we will be able to provide answers in the future. Given the broader data sets that were drawn upon for KFD, it will be a simple matter (conceptually, if not practically) to couple multiple fields and systematically explore the nature and patterns of coauthorship ties within and between disciplines. This, too, is part of our future agenda.

The notion of a core-periphery structure is used widely in social science studies of social structure. Yet, in many ways, it is used loosely with little attention to specific and multiple forms of, so called, core-periphery structures. The (potential) catalogue of these structures is far from complete. In KFD, we report multiple core-periphery structures and we anticipate that this collection of potential structures will expand with further uses when other disciplines are studied. The idea of a bridging core strikes us a particularly important feature of national science systems, as noted by Light and Moody in reaction to KFD. Everett notes that the (multiple) cores are small. We think this may be a feature of the (relatively) small sizes of scientific systems in Slovenia. Everett is correct to note that one part of some of the Slovene scientific systems (and not just for sociology)—which we called the semi-periphery—is characterized more by ties within it than with ties to any of the cores. This is important for at least three reasons: (i) it is a valid description of the structure of this discipline; (ii) it expands the catalogue of core-periphery types and (iii) it has major implications for blockmodeling. We focus on the last two of these reasons.

An assumption of the study of core-periphery systems seems to be that the real action of a system goes on within the core and through ties between the core and the rest of a social system. Our results suggest that "it ain't necessarily so" and that it is productive for the study of science to explore the contributions of these different parts of scientific systems separately and in conjunction. There is evidence supporting the claim that, for Slovene sociology, there is a greater amount of high quality generalizable research being conducted in the semi-periphery than in the cores. We will be exploring this further in an effort to understand the conditions under which this occurs and the implications that this sort of structural form has for the discipline (or any discipline with this kind of structure.)

In terms of generalized blockmodeling Doreian et al. (2005), and using the direct approach, a blockmodel is specified and fitted by minimizing a criterion function that operationalizes a specific type of equivalence. The criterion function summarizes the total number of inconsistencies between a fitted blockmodel and the closest ideal blockmodel for the type of equivalence that is used. In general, once the blockmodel is fitted, the value of the criterion function plays no further role beyond helping to identify the best blockmodel(s) for the data. Attention is then focused on the delineated blockmodel structure in terms of the block types and their locations. We report this in KFD in our use of multiple cores and the idea of bridging cores. Strictly, the block type for the ties inside the block for the semi-periphery is a null block. In general, while the presence of null blocks in networks has structural significance, there is not a lot that can be written about the form of a null block. However, in the models reported in KFD there are more than a few ties in this null block and, at a minimum, this suggests that we need to pay more attention to the internal structure of this (or any) block when there are a large number of departures from the corresponding ideal block. This can be done by characterizing, for example, the graph theoretical structure of the network inside the semi-periphery positions reported in KFD. This could also be done with a second round of blockmodeling which suggests the value of considering two-step (or multiple-step) blockmodeling both in terms of methods and, perhaps more importantly for studying science, in terms of substance.

Both Everett (2011) and Light and Moody (2011) direct our attention also to the external forces or shocks that can affect any system including scientific systems. Rightly, Everett takes us (mildly) to task on this issue for not disentangling potential external forces and their potential impacts on Slovene scientific systems. We mention Slovenia achieving independence in 1991 and the movement towards integration with wider European institutions along with the upsurge of internet connections internal to nations and between them—but we do not try to separate these forces. The causal standing of our Hypothesis 4 "The collaboration culture of the natural sciences has been present for a long time in Slovenia. In contrast, collaboration in the social sciences gained its relevance in the last ten years, mainly because of the pressure towards the internationalization of the Slovenian science" remains in question given the evidence presented in KFD. This is something we need to address. One step towards doing this is to look more closely, on an annual basis, at collaboration behavior as a complement to summaries for five year periods. We will also be launching a qualitative study of the reasons provided by Slovene scientists for their collaborative behavior via an implementation of a web questionnaire.

All of these responding remarks are little more than a preamble to the deeper topic of network dynamics and network evolution. While the structures revealed by the disciplinary blockmodels are nice characterizations of the structures of four disciplines for four consecutive five-year periods, they are but a set of structural snapshots evenly spaced over time. We did not provide a substantive account for why these structures move between forms described as multiple cores to consolidated cores and, for some disciplines, move back to a simpler form. This could be due to the operation of the external forces that both Everett (2011) and Light and Moody (2011) mention or it could be due to internal disciplinary dynamics. While it is safe to claim that both forces may have been in play, we do need to look at these changes more closely. To that end, we are examining changes in a variety of ways. One was started in KFG by looking a core membership between time points and institute memberships over time. For the former, we documented that some cores at one time point had disintegrated by the next time point (KFD: Figure 9). Members of different cores came together in a new core at the next time point while some members went to the semi-periphery. Even though it is remarkable that some form of a core-periphery structure remained in place despite these dramatic changes perhaps as a self-organized system property we presented no coherent substantive argument for why. We suspect that there were subtle interplays of field based forces, interdisciplinary forces and external forces together with the dynamics of individual career moves occurring while scientists age. These are all topics we intend to pursue given the rich description of content and employment histories in the data. Additionally, we intend to look closely at the implications of the KFD result that the four scientific disciplines expanded primarily by recruiting new members to the semi-periphery and the periphery.

We are at work with a completely different data analytic approach by using SIENA Snijders (2005) to tackle some issues concerning these temporal dynamics. A longer range goal is to couple exponential random graph models (ergms) and blockmodels into a single coherent modeling framework for studying scientific structural change. In this context, the partial history of blockmodeling provided by Light and Moody is instructive. The arrival of blockmodeling (in 1971) was a superb intellectual achievement that was based on the substantive concern of understanding the structure and operation of role systems. Over time, it seems that blockmodeling became known as strictly a methodological approach for discerning the structure of any social network. And while the tools were used as such, it seems that the early promise of a substantive understanding of network structure and dynamics was not realized. This may help account for the Web of Science data reported by Light and Moody (2011) where the most cited items are to the older foundational statements. While a lot of separated blockmodeling studies were conducted, there was little by way of cumulated knowledge of social structure and changes in social structure. This concern motivated the development of Generalized Blockmodeling Doreian et al. (2005) to provide a more general treatment of blockmodeling and to secure its foundations. Included in this document was an expansion of the types of blocks and hence blockmodel structures, as well as the use of pre-specified blockmodels. While it would be nice if this book in its nascent citation life (to use Light and Moodys delightful term) came to have greater influence on current research, the content of the book did have some limitations. In the context of studying scientific systems, two are particularly pertinent.

Everett points one of them out explicitly: While the data on scientific coauthorship are valued data, they were treated as binary data for the blockmodeling. We agree with him that it will be useful, even necessary, to take advantage of the information in the valued network ties. Ziberna (2007) suggests ways in which this can be done and makes it clear that doing so is non-trivial task. Generalized Blockmodeling had a lot to say about structure but included very little regarding the evolution of blockmodel structures nor the evolution of network structure. Light and Moody comment on the awkwardness of dealing with network evolution and added it is difficult (Figure 9 not withstanding) to get a good sense of how positions in the network change over time. Again, we agree. Coupling blockmodeling to ergms, as proposed in Doreian et al. (2009), will take us part of the way towards getting a better sense of the co-evolution of network structure, positions and individual scientific careers.

Light and Moody also point to new techniques that show promise of being valuable in studying change of time of network structures and provide some citations. We will consult those sources because we are convinced that multiple network methods are needed for studying social networks, including national scientific systems. Thus, while KFD used primarily blockmodels for this task, we do not claim that they are the best way of doing so. Certainly, they are not the only tools that will be useful for the task of comprehending structure and structural dynamics. We have a wonderful data set to explore the dynamics of scientific systems and a broadening set of methodological tools. We know also that the only legitimate criterion for success will be the creation of valid substantive understanding that matters. Using only one technique to get there will not be an option.

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