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THE CONSTRUCTION OF THE ACADEMIC WORLD-SYSTEM: REGRESSION AND SOCIAL NETWORK APPROACHES TO ANALYSIS OF INTERNATIONAL ACADEMIC TIES

Maria Safonova[1] and Mikhail Sokolov[2]

[1] *msafonova@eu.spb.ru*
Higher School of Economics, Soyuza Pechatnikov Str. 16, 190008, St.Petersburg (Russia)

[2] *msokolov@eu.spb.ru*
European university at St.Petersburg, Gagarinskaya Str. 3ª, 191187, St.Petersburg (Russia)

Abstract
This paper explores factors responsible for strength of various forms of academic ties between countries. It begins with examining several theoretical models of international academic collaboration: "the republic of letters", "academic (neo)colonialism", "the classical world-system", and "the world-society". Propositions about factors affecting intensity of ties between countries and configuration of their overall network are then derived from each of the models. These propositions are then tested against empirical data on two kinds of academic ties: volumes of international student flows between pairs of countries (UNESCO statistics) and number of co-authored papers (Web of Science database). Negative binomial regression is used to estimate influence of various independent variables (funding of science, distance, historical experience of dependency) about the significance of which the models make different predictions. We discover that expectations associated with "the classical world-system" fit the data best, with "academic neo-colonialist" factors also important in the case of international student flows. To account for possible differences between disciplines and to capture the directions of evolution of the system, we then explore changes in international collaboration network in two fields: geoscience and economics during a 30-year interval (1980-2010).

Conference Topic
Collaboration Studies and Network Analysis (Topic 6)

The theoretical models

Our thinking about the global system of academic collaborations is torn apart between two conflicting images. One of them, essentially optimistic, is the vision of the *international republic of letters* "as a prototype of truly open and democratic society" (Polanyi) governed by egalitarian and meritocratic norms (Merton). While modern sciences originally emerged in the West, and were exported to the rest of the world in the course of colonization, the classical modernization theory held that formerly peripheral countries would eventually

pass the stage of colonial science and develop national academies attaining full-fledged membership in the global system of division of intellectual labour (Basalla, 1967).

Another vision, essentially pessimistic, is that of hierarchical and exploitive "academic world system". This argument has been developed since the 1960s in a variety of forms, all of which vigorously opposed the earlier idealistic vision. Considering each other as allies, the adherents of these views used to downplay the disagreements in their own camp. The further classification of three types of scepticism concerning global science is thus not present in the literature itself, but can be derived through its careful review.

According to different *neo-colonial theories*, the former colonies never attain full-fledged membership in the global academic system as they remain bound to their metropolitan countries by various institutional and symbolic ties, traditional considerations of prestige, etc. (see a collection of such arguments in Sardar, 1989). The colonial infrastructure (especially educational system which was built following the imperial centre model) reproduces imperial language use and certain type of dispositions and identities (Altbach, 2004; Foner, 1979; Murphy-Lejeune, 2001; Tremblay, 2002). Moreover, since the contours of old colonial relationships are re-created at the level of contemporary international agreements in the educational sphere, application procedures and conditions of educations are simplified for young people from former colonies. That results in so-called "brain circulation": a phenomenon created by return of former skilled-labour migrants into their home countries (Cheng and Yang, 1998). Their employment in the home-country universities and research centres generates, firstly, international collaboration teams on the basis of personal networks of former migrants and, secondly, new incentives for student mobility between a former centre and a colony. That reproduces dominance of the metropolitan countries over its former colony even in absence of direct political dependency.

According to the *classical world-system theory*, in conditions of initial economic and technological inequality between the centre and the periphery most forms of interaction work to further detriment of the latter. Scholars of the "core" countries specialize on the most advanced forms of research, while the peripheral academies produce raw data, perform technical tasks, and send away their best students. The unequal division of labour arises from the fact that scholars from wealthier countries can contribute more in terms of funding, costly equipment, and infrastructure. That makes them sought-after partners and gives them an advantage in negotiating conditions of collaboration. Moreover, due to resources at hand, they have more opportunities to develop ideas produced elsewhere. The regime of academic openness gives an advantage to scholars from economically more advanced countries which also benefit from their greater potential for technological implementation of ideas. Classical world-system and neo-colonial approaches are indiscriminately united under the heading "dependency theories" (e.g. Arnove, 1980), although the former stress economic, while the latter –

institutional and cultural aspects of dependency[34], and in some respects they propose contradicting implications for how the network of global academic ties would look like. Firstly, the neo-colonial theories suggest that the networks will be clustered along the lines of former colonial allegiances, while the classical world-system implicates existence of a single relatively unified core. Secondly, the world-system approach suggests that there will be strong interaction between wealth of a national academic system and distance of its ties, with the richer having more long-distance partnerships, and the poorer less (we are not aware of this hypothesis being discussed in the literature on academic collaboration, but it parallels one well familiar from studies of international trade). The neo-colonial theories believe that transportation costs are secondary to different types of transaction costs arising from institutional and cultural closeness (North, 1991).

In its original formulation, world-system theorizing suggested that their will be lack of scholarly activity in the peripheral countries altogether, with most kinds of intellectual production concentrated in the core countries (the possible exceptions were types of research directly meeting demands from backward peripheral economies). Empirical studies demonstrated, however, that the spread of higher education and research sectors in the XX century was surprisingly uniform in all countries irrespective of their level of economic development. The *world-society theories* developed by John Meyer and his many associates sought to explain this fact by pointing to emergence of single rationalized global culture which is imitated even in absence of any direct economic pressure to do so (Schoffer, 2003; Meyer and Schoffer, 2005). A few studies in the "world society" tradition demonstrated that, counter to what economic determinism of the classical world-system analysis assumes, scale of national investments in research and research education neither responds, nor immediately contributes to economic growth, or may be even detrimental to it (Shenhav, 1993; Schofer, Meyer and Ramirez, 2000). The world-society perspective differs from the neo-colonial approach in focusing on singular world-society, rather than dispersed academic empires. The patterns of collaboration in this world-society, however, emerge under the pressure of cultural, rather than economic, necessities. The classical world-system implies that centrality of a given national academy in the network of international academic ties is directly related to its economic prosperity. This pattern is likely to be most salient in the case of capital-intensive disciplines, involving high-cost experimental or field research. The world-society assumes that prosperity will be secondary to traditional intellectual prestige of a given country (not necessarily related to its prosperity), and that there will be no differences between disciplines.

Parallel to that theoretically-driven efforts, a bulk of more empirical research on international collaboration emerged in the scientometric tradition which demonstrated, among other things, a strong tendency for geographic localization

[34] The distinction between the two arguments becomes somewhat blurred if we consider institutional-economic factors, which are typically omitted from world-system theorizing, but figure prominently in sociological approaches to migration (namely, migration systems theory (Kritz, Lim and Zlotnik, 1992) and migration network theory (Gold, 2005; Massey at all., 1993).

of academic collaboration (e.g. Luukonen *et. al* 1992; Zitt *et al*. 2000). Regretfully, to our knowledge, there were no attempts so far to control for influence of other variables (e.g historical or economic, which are likely to be intertwined with purely geographic). The only partial exception seems to be (Nagpaul, 2006), although his paper does not account for cultural or historical factors. There were little attempts to bring closer the quantitative bibliometric and more historical and sociological literatures (but see Schott, 1998 for an early exception). The most recent theoretical formulations emerging in scientometric literature tended to downplay the role of external factors in formation of academic ties altogether, pointing to self-organization system properties of networks (Wagner and Leydesdorff, 2005a; Wagner and Leydesdorff, 2005b). This contradicts, however, many early findings which demonstrate prominence of extrinsic factors in tie-formation on micro-level. The network science, nevertheless, offers a valuable null-hypothesis which states that none of the characters of the pairs of countries will influence the intensity of ties between them, except their sheer size.

Table 1. Theoretical models and their empirical implications: effects of various variables on intensity of academic ties

Table	*Republic of letters*	*Neo-colonial*	*Classical world-system*	*World-society*
Wealth and research funding	Secondary importance or none	Secondary importance or none	Primary importance, especially for capital-intensive disciplines	Secondary importance or none
Physical distance	Secondary importance or none	Secondary importance or none	Primary importance for poorer countries	Secondary importance or none
Institutional ties	Secondary importance or none	Primary importance	Secondary importance or none	None
Overall network pattern	Cohesive. Clustering, if any, based on national research priorities (in applied fields).	Strongly clustered, homophily between institutionally coupled countries	Classical core-periphery, with position solely dependent on wealth; clustering at periphery based on proximity	May be cohesive or core-periphery; centrality (if any) based on established prestige, no clustering.

The aim of this paper is to evaluate the theoretical models listed above by exploring systematically factors responsible for formation and strength of academic ties. We take two types of ties, corresponding to different stages in academic careers and different, though overlapping, sectors of academic institutions: (1) international student migration flows and (2) scholarly paper co-

authorships. We then try to evaluate the models in two ways: directly, by using regression analysis to predict intensity of migrations and collaborations between pairs of countries, and indirectly, by applying social network analysis measures to evaluate overall network pattern (see Moody, 2004 for an exemplary studies). The rationale behind these steps is that different models have different implications for which factors will strengthen the ties, and how the whole network will be organized. These implications are summarized in Table 1.

The expectation based on the republic of letters model is the existence of relatively cohesive network, the centrality of position of a specific country in which is primarily determined by the number of students and high-school teachers (in the case of student migrations) and total academic personnel (in the case of co-authorships) available in it. Homophily, if any, occurs between countries which similar research priorities (which might arise from common economic necessities, especially in the case of applied sciences). Other factors are deemed secondary.
In the case of neo-colonial model, the network becomes highly clustered with clusters corresponding to former colonial empires. Here instead of a single core-periphery structure, a series of such structures emerges, with each core country having its own periphery, most likely, the one to which it has exported language and educational institutions as a colonial centre. The student flows from former colonies go to the former metropolitan countries, with metropolitan students mostly studying at home. Co-authorship also occurs mostly inside the boundaries of former empires. Prestige of a traditional centre might be reproduced even in presence of economically strong rivals, thus making wealth secondary. We could expect that, due to low transaction costs (common language and institutional similarity), intensive academic ties will emerge between pairs of former colonies of a single imperial centre as well.
In the case of the classical world-system, our expectation would be that the whole system is patterned as a prototypical core-periphery structure with few, if any, contacts between peripheral agents situated in close proximity to each other. Its exact shape may vary with the character of the discipline. In the case of capital-intensive disciplines, scholars from one prosperous academy would prefer partners from academies which are also prosperous, especially when production and consumption of knowledge in a given discipline is global. Similarly, students from wealthier countries have more chances to study abroad as they are more likely to get scholarships at home or to invest family resources; that makes them much more attractive entrants the point of view of universities, especially the private ones. Thus, reasoning by analogy with what sociologists of science observed at the intra-national level, a system aptly called “academic castes” emerges (Burris, 2004). According to it, the academic world is a stratified system, in which exchange is limited to the members of the same strata. Projecting it on the global system of academic collaboration, one might expect that the academics from the core-countries are likely to be overrepresented among the co-authors of academics from other core countries, while semi-peripheral academics would

have to look for partners in their own league; the academics from the periphery probably would find themselves isolated. The picture may be different in disciplines which are labour-intensive, or in which knowledge is locally produced (e.g. involving excavations or cross-cultural comparisons). Here the caste barriers disappear, although direct collaboration between peripheral countries still rare. Corresponding pattern in organization of student flows would look like system of asymmetric exchanges with upper-caste countries sending incoming flows to each other, while lower castes send flows to them without receiving any students in response.

Finally, in the world-society model scholars and academic institutions from all countries are under equally strong pressure to collaborate internationally, as that increases legitimacy of their work. They might be quite indifferent between particular partners (producing cohesive network), or to prefer partners belonging to the academic systems which are considered to be in highest compliance with the requirements of the "world society" (producing a core-periphery structure). Being a paragon of "world society", however, does not necessarily depend on wealth or funding. Here we do not expect to find principal differences between disciplines as all of them have to demonstrate compliance to a single legitimate pattern.

Data, measures and methods

The major sources of data were, firstly, UNESCO Institute of Statistics, and, secondly, Thomson Reuter's "Web of Science" databases. For all regression calculations, 2007 year was used as the data on it were the most complete of those available. We included only those countries for which at least population and the GDP data were available, which gave us a sample of 181 cases. In addition to that, we gathered co-authorship data on two disciplines (geoscience and economics) for 1980, 1990, 2000 and 2010 years. The rationale for choosing these particular disciplines was that we wanted to have a natural and social science to compare. Of the social sciences, only economics seemed suitable as other disciplines simply do not produce enough cases of international co-authorship in a year. To match it on the part of the natural sciences, we wanted to find one which would be the closest in the sense of its results being at least partly locally produced and locally consumed. Geoscience seemed the best fit from this point of view.

The dependent variables were two kinds of links between pairs of countries – (1) volume of international student flows, (2) number of papers scholars from them co-authored in the Web of Science database. The independent variables were either attributes of the countries (GDP, tertiary student population) or characters of relations between them (proximity, experience of colonial dependency or co-dependency).

Dependent variables

Student flows

The data on student flows between pairs of countries were taken from UNESCO datasets which accumulates reports from recipient countries on the numbers of foreign students coming to study in them. The data for 2007 were available from 73 countries (of 209 UNESCO recognizes). Western countries were heavily over-represented in this sub-sample (as nearly all EU countries have produced required statistics). That posed a problem for further analysis. Including all existing data on international flows (12977 valid cases) would probably result in over-estimation of whatever factors influenced volume of flows from non-Western to Western countries as the cases of flows between non-Western countries would be disproportionally under-represented; at the same time, limiting the sample to the 73 countries which have published statistics (5285 valid cases) would exclude most non-Western countries altogether, and thus under-estimate influence of variables pertaining to core-periphery differences. As a solution, the analysis had been performed on both extended and reduced samples. Predictable changes in coefficients occurred, but no significant differences were observed. Below calculations performed on extended sample are reported.

Co-authorships

The data on co-authorships between pairs of all 209 countries included into UNESCO dataset were extracted from Web of Knowledge Science, Social Sciences, and Arts & Humanities databases for 2007; papers in all languages were included, but conference proceedings omitted. A difficulty arouse from the fact that the UNESCO and WS lists of countries differed. For example, WS does not provide users with separate data on Macao or Hong Cong (which are treated by UNESCO as state-type entities); at the same time, it recognized England, Scotland, Wales, and Northern Ireland as separate states, but we had to merge them as UNESCO provides only aggregated statistics. That reduced the list of cases suitable for analysis to 177 countries; we thus had 15576 ($(177^2 - 177) / 2$) valid pairs.

Independent variables

Populations

All four models recognize the importance of the size of academic populations which thus functions as a control variable. UNESCO gathers data on (a) *numbers of tertiary students* studying in the country (estimate of potential student flow from a country); (b) *numbers of higher education teachers* (estimate of the accommodating capacity of a given national higher education system)[35]; (c)

[35] This variable is not truly independent as, in the long run, it is endogenously determined by the size of the flow. Thus, it was not included in the analysis.

numbers of researchers (estimate of numbers of potential co-authors). The problem which plagued these data were missing values; as of 2007, 149 countries (of our 177) provided data on tertiary enrolment, 127 – on numbers of high school teachers, and only 97 on researchers in head count; 4 more did that in full time equivalent.[36] Again, the Western cases were heavily over-represented.

Proximity

We used the UNESCO classification of countries into 21 regions and converted these data into binary variables, assigning "1" if both countries belonged to the same or adjacent regions, and "0" otherwise.

Wealth and gross academic expenditures

(a) Country wealth was estimated by GDP per capita (available for all countries in all three of the samples, source – UN statistics); *(b) National academy's wealth* was estimated by Gross Expenditure on Research and Development (GERD) per researcher. GERD data was available for 105 countries (in 15 cases data were extrapolated from adjacent years in the interval from 2004 to 2008). In 94 of these 120 cases, the data on numbers of researchers were also provided. Availability of GERD data was the single most important limiting factor on selecting the valid cases for analysis of co-authorships; what is more, selection of cases on the basis of availability of statistics on research again favors Western cases against non-Western which is likely to somewhat downplay the importance of the next group of factors. We used GDP per capita as a proxy for wealth of the national academy for most calculations, as it allowed avoiding loss of cases and the correlation between this measure and GERD per researcher reaches .5 size.

Political dependency and co-dependency

We used historical experience of dependency both to directly test the neo-colonial model and as a most general proxy for probability of massive institutional import. We created a binary variable, assigning "1" if one of the countries at certain moment since 1648 were governed by the central government situated at the territory of the other, and "0" otherwise.[37] A former colony can be economically and political successful, and create strong national academy, or even establish its own quasi-colonial system (as the US did, see Mann (2008). In that case it would benefit from primary language and institutional export of its former metropolitan country, and compete with it for oversees resources (students and collaborators). The US and the UK, or Germany and Austria could serve as examples. To account for this fact, we created an additional *"political co-dependency"* variable,

[36] We converted FTE in HC by dividing it by 0.62 (average, S.D. = 0.06) to receive 101 valid attributes.

[37] That not necessarily means colonial dependency. In some cases we dealt with dissolved political unions of a more egalitarian character, e.g. Czechoslovakia. Colonial empires, however were by far a modal case.

"1" for countries which were in certain moment under rule of a central government situated in a territory of a third country and "0" otherwise.
A square matrix was created, where relations of a colony or a dependent territory and a metropolitan country coded as a link between the two countries (binary).[38] Data on absence or presence of a tie were used as an independent variable ("historical experience of political dependency of B from A"). Matrix with geodesic distances was created from the first matrix, and data on geodesic distance of two were extracted to include relationship of belonging to one "colonial neighborhood" as an independent variable into the model ("historical experience of political co-dependency of B and C from some A").

The Regression Model

Both dependent variables were distributed obviously non-normally, with zero being the modal value. Moreover, their standard deviations were much greater, than mean, signaling overdispersion. The distribution closest to the observed would be the negative binomial one. To deal with overdispersion, the scale parameter has been set equal to deviation. Interaction terms for countries' wealth, and research expenditures were included. Regression with robust error variance was used to help remedy non-independence of cases.

Results

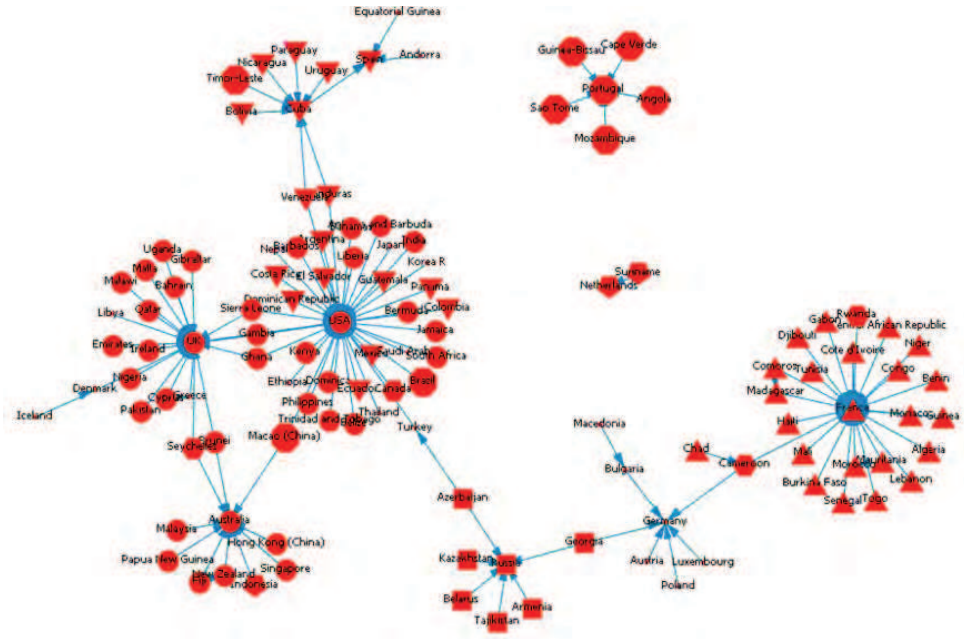
Table 2 shows results of regression of volumes of student flows between countries on independent variables (extended sample, 73*181).

Table 2. Regression model predicting volume of a student flow between pairs of countries

Table	*Wald Chi-Square*	*Sig*	*Exp (B)*
Intercept	221,826	,000	2,866
Tertiary student in the sending country (MLN)	277,694	,000	1,313
Proximity	613,969	,000	11,746
Sending country GDP per capita (PPP $000)	28, 235	,000	,981
Receiving country GDP per capita (PPP $000)	1016,419	,000	1,084
Dependency	215,605	,000	28,827
Co-dependency	144,314	,000	3,308
Interaction: Proximity & Sending Country GDP	47,434	,000	,968
Interaction: Dependency & Sending Country GDP	22,707	,000	,953
Interaction: Co-dependency & Sending country GDP	,432	,511	1,004
Interaction: Countries 1&2 GDP	103,988	,000	1,001
Likelihood Ratio Chi-Square 5431,613		,000	

[38] The date was chosen rather arbitrarily, as a traditional landmark in the history of international relations. If part of a presently existing country were colonized by another, while others were not (e.g. parts of China under British and French rule), we assigned "1" if the respective part exceeded 10% of the present country's territory.

The coefficients demonstrate, first of all, predictable importance of size of the emitting academic world. The volume of student flows between countries is positively correlated with wealth of the destination country, but negatively – with wealth of the country of origin. Richer academic systems posses a sort of social gravitation which attracts student flows from outside, at the same time keeping students from inside from leaving. Other things being equal, students from wealthier countries are less likely to study abroad, and if they become internationally mobile, they chose other prosperous countries. At the same time, the directions of mobility are heavily pre-determined by historical and institutional factors. That finding could be easily supported by inspection of a map of flows, bringing with them more, than 30% of international students from a given country (ORA visualizer used). These deep migration channels link former imperial centres with their once-colonies.[39]



Picture 2. "Deep channels" in international student migration

Co-dependency is significant as well, but less so. Proximity also plays role, albeit two and a half times less massive, than former dependence, judging from Exp(B) coefficients. Finally, proximity and wealth, and dependence and wealth interact, showing that (1) there is a difference in the range of educational migration by students from poorer and wealthier countries with the latter travelling further; (2)

[39] The form of the sign corresponding to a node shows the language which is used in the country as official (English, Spanish, French, Russian, Dutch and Portuguese respectively). I-E Index for language attribute is -0.349, $p < 0.0001$.

students from poorer post-colonial countries are more likely to travel to their metropolitan country, benefiting from its paternalistic policies and relying on existing migration channels to save on transaction costs.

These findings obviously do not fit with the vision of "flat world", equally open to all, which "republic of letters" implies. In addition to evidence of effects of all kinds of economic and political factors, one observes that the countries gravitating towards each other tend to be dissimilar in terms of academic development, and, thus, are unlikely to have similar political priorities. The results even less fit with the world society theory which is probably overestimating spread of rationalizing culture around the globe, especially as far as higher education sphere is concerned. The "core" of the academic world system is fractured between older and newer colonial powers. Overall, both versions of the dependency theory receive some support: we do see academic castes, and we do find a heavily clustered network, especially at the periphery.

The picture changes as we turn to international network of co-authorships. Table 3 summarizes what we observe there.

Table 3. Regression model for co-authorship

Table	*Wald Chi-Square*	*Sig*	*Exp (B)*
Intercept	270,576	,000	,319
Researchers in both countries (UNESCO head count, 000)	1738,267	,000	1,004
Proximity	367,200	,000	5,283
GDP per capita in country 1 (PPP $000)	459,746	,000	1,059
GDP per capita in country 2 (PPP $000)	491,871	,000	1,058
Dependency	22,072	,000	2,836
Co-dependency	88,928	,000	2,651
Interaction: Countries 1&2 GDP	20,695	,000	1,001
Interaction: Proximity & GDP per capita	48,518	,000	,974
Interaction: Dependency & GDP per capita	,008	,930	1,001
Interaction: Co-Dependency & GDP per capita	22,158	,000	0,976
Likelihood Ratio Chi-Square 13353,875		,000	

As co-authorship relationships are essentially symmetric (or, at least, there are little opportunities to decipher any asymmetries authors lists conceal), we summarized data on populations of researchers in both countries to obtain combined variable. Not surprisingly, it is highly significant. GDP per capita in both countries and their interaction are significant as well, signaling the tendency of academics from more prosperous academic worlds to look for other resourceful partners. Producers of scientific papers are divided into economic strata.[40] Finally,

[40] We are not discussing here the possibility that participation of scholars from less resourceful academic systems is not recognized by authorship. More detailed case research is necessary to prove or falsify this disquieting suspicion

colonial variables retained their significance, albeit at a diminished scales. Proximity matters more, and we encounter again interaction between long-distance collaborations and wealth. A significant detail is that while in migration equations exp (B) coefficients for colonial dependency were twice as large as they were for colonial co-dependency, here they draw much closer. An interpretation of this might be that policies of former metropolitan countries which advantage students from former colonies are usually not spread to adult academics. Finally, we find interaction between wealth and co-dependency, but not wealth and dependency. It means that scholars from poorer academies tend to co-author papers with scholars from other countries formerly dependent from the same colonial centre, but not from the centre itself, probably pointing to the fact that former colonies and former metropolitan countries tend to belong to different "academic castes".

Overall, we see that the pattern of international co-authorship even more clearly follows the expectations based on classical world-system, than that of student migration flows. Formation of research partnerships are obviously not completely a stochastic results of network growth, as proponents of the network science would like us to think (Wagner and Leydesdorff, 2005a); the geographic, economic, and institutional factors together produce McFadden R^2 of 0.215. The academic castes are quite salient with scholars from wealthier academic worlds preferring their likes. Cultural and historical legacies remain significant, although at a lesser scale.

The cases of geoscience and economics

At the final stage of our analysis, we looked at evolution of two specific fields to find out, if there are differences between disciplines, and if the development occurring in them is in one and the same direction. Table 4 presents data on economics, Table 5 – on geoscience.

Table 4. Parameters of economics network

Table	*1980*	*1990*	*2000*	*2010*
Nodes	56	63	107	140
Edges	102	164	752	1790
Density	0.033	0.042	0.066	0.092
Transitivity	8.83%	6.46%	16.14%	21.73%
Clustering coefficient	0.225	0.172	0.366	0.454
Centralization (Degree)	8.54%	5.82%	5.00%	4.32%
GK Gamma correlation with Dependency	0.421	0.685*	0.778***	0.810***

In accordance with already reported findings (Wagner and Leydesdorff, 2005b), a rapid growth occurs in both networks, which are also becoming denser and less

centralized.[41] In contradiction to what Wagner and Leydesdorff propose, however, transitivity and clustering coefficients in both networks grow significantly as well, meaning that international collaboration in both disciplines becomes at the same time more, rather than less, fragmented. We calculated Goodman-Kruskal Gamma correlation between dependency and intensity of tie. Astonishingly, the correlation rose from insignificant to very strong. The growth of international collaboration makes the contours of academic empires more, rather than less, visible. Equally surprisingly, there were no marked differences between disciplines, hinting that the processes of academic globalization do not depend on usually assumed epistemological differences between social and natural sciences as such.

Table 5. Parameters of geoscience network

Table	*1980*	*1990*	*2000*	*2010*
Nodes	59	86	140	158
Edges	190	462	1522	3322
Density	0.055	0.063	0.078	0.134
Transitivity	14.27%	15.71%	19.62%	23.05%
Clustering coefficient	0.333	0.359	0.423	0.473
Centralization (Degree)	9.02%	7.89%	5.67%	4.95%
GK Gamma correlation with Dependency	0.594*	0.852*	0.852***	0.898***

Concluding remarks

Obviously, the attractive vision of "republic of letters" is far from harsh realities of international Academy in which economic inequality is central to setting patterns of collaboration and mobility, and inherited cultural and institutional divisions remain all-pervasive. There is a tendency for the scholars from the core countries to form closed clubs by choosing co-authors from wealthier countries as partners. Overall, it seems that academic co-authorships tend to form academic caste structures (as the world-system theory predicts), while student mobility flows are more segmented by colonial legacies (as neo-colonial theory predicts). Finally, the uniformity of the world-societal pressures are probably strongly overestimated as far as academic world is concerned.

No doubt, taking into account the limitations of data processed, these conclusions are to be treated as tentative at best. Including more formal measures of similarity of research profiles of countries (e.g. based on distribution of their publications among different categories in Web of Science) is necessary to do more justice to the "republic of letters" model. An obvious omission of this study is

[41] These considerations do not take into account distortion which may arise from logic of growth of the Web of Science database. Increasing density might be an outcome of wider inclusion of peripheral periodicals, rather than actual growth of collaboration (Passi, 2005). To our knowledge, however, no remedy for potential bias emerging from this has been offered so far.

indiscriminate usage of one measure for "dependency". A variety of measures should be computed to take into account (a) the longevity of belonging to a common political system; (b) the particular historical period of belonging; (c) the part of territory covered by it; and (d) other historical particulars of colonization. Imperial centres differed in their approach to exporting educational institutions to the colonized territories, and some of them attempted to meticulously reproduce metropolitan Academia on the new soil, while others did not care much about institutional export at all, or even imported institutions from territories they happened to acquire (as Muscovy, and later the Russian Empire, from Ukraine and the Baltic region). More historical analysis is necessary to account for such differences. Finally, larger sample of cases of academic specialties is necessary to reach any reliable conclusion about differences between disciplines. This list is to include capital- and labour-intensive specialties (intuitively, geoscience seems much more capital-intensive, than economics, but some more formal measures are desirable here). Varieties along the dimensions of local-global production and consumption of knowledge are to be appreciated as well. All these suggests some avenues for further work.

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