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Internationalists and Locals: International Research Collaboration in Resource-Poor Systems

(*preprint*)

Abstract

The principal distinction drawn in this study is between research "internationalists" and "locals," the former being scientists involved in international research collaboration while the latter are not. These two distinct types compete for academic prestige and professional recognition, research funding, and international recognition in science. As a clearly defined subgroup of Polish scientists (51.4%), internationalists are a different academic species. They are predominantly male and older; they have longer academic experience and higher academic degrees, and they occupy higher academic positions. Internationalists co-author internationally six times more often than locals. Across all academic clusters, internationalists consistently produce more than 90% of internationally co-authored publications: no international collaboration means no internationally co-authored publications. Internationalists are much more productive in terms of internationally co-authored publications: 2,320% of the productivity of locals for peer-reviewed articles and 1,600% for peer-reviewed article equivalents. For English language peer-reviewed articles, the figure is 290.9%, and for article equivalents, it is 276.5%. They are also about 70% more productive in terms of conference papers and about 50% more productive in terms of peer-reviewed articles, article equivalents, and books. Internationalists tend to spend less time than locals on teaching-related activities, more time on research, and more time on administrative duties. Finally, the multivariate analyses identified some new predictors of international research collaboration. Based on a large-scale academic survey (N = 3,704 returned questionnaires) of Poland's resource-poor higher education system, this study has global implications for academic career, productivity patterns, and internationalization policies.

Keywords

Collaboration; academic career; productivity patterns; internationalization; Poland

Introduction

The principal distinction drawn in this study is between research "internationalists" and "locals," the former being scientists involved in international research collaboration while the latter are not. These two distinct types compete for academic prestige and professional recognition (Wagner and Leydesdorff 2005), research funding (Jeong, Choi, and Kim 2014), and international recognition in science (Merton 1973). While locals produce knowledge for "national research markets" and audiences (Ziman 1991), internationalists produce knowledge for international (or local and international) markets and audiences. As reward systems operate differently across countries and academic disciplines (Merton 1973), seeking international recognition is reported to be more or less "necessary" (Kyvik and Larsen 1997: 260), depending on country affiliation and discipline.

Academic discipline, employing institution and type, and national reward structure all matter for international collaboration. However, the decision to internationalize is ultimately personal, and concepts such as "self-organization" (Wagner and Leydesdorff 2005: 1610; Melin 2000: 39; Wagner 2018: 84) and "informal collaboration" (i.e., conducted outside formal agreements) (Georghiou 1998: 612) are especially relevant in this regard. Within the global knowledge network, the motivation to internationalize comes from scientists themselves, and "political ties or national prestige do not motivate the alliances of researchers" (Wagner 2018: viii). Faculty internationalization is reported to be disproportionately shaped by deeply ingrained individual values and predilections (Finkelstein, Walker, and Chen 2013). Scientists compete for recognition (Merton 1973; Cole and Cole 1973; Zuckerman 1970) but vary in their tendency to collaborate internationally: "The more elite the scientist, the more likely it is that he or she will be an active member of the global invisible college"—that is, collaborating with colleagues in other countries (Wagner 2008: 15; Kwiek 2016a).

Previous studies have shown that the share of internationalists among Polish academics is substantially lower than the European average, and their role in the Polish academic knowledge production is substantially higher (Kwiek 2015a). From a European perspective, Poland is among those countries with the lowest share of internationalists. In a recent study of 11 countries, the mean share of internationalists among scientists employed full-time in the university sector was 63.8% (Kwiek 2018b); in Poland, internationalists account for just 51.4%. As in the other European countries studied, top research performers (i.e., the top 10% of scientists in terms of average research productivity) are responsible for about half of all academic publications and are highly internationalized (Kwiek 2016a; Kwiek 2018c). However, in terms of international collaboration growth, Poland was ranked lowest among 52 countries studied by Gazni, Sugimoto, and Didegah (2012), with a significant decline in internationally co-authored publications during the period 2000–2009. This was followed by a slow increase in 2010-2017 (from 28.4% to 32.9%) (SJR 2018), related

to the reinstitutionalization of the research mission in Polish universities (Kwiek 2012) within new waves of higher education reform (Dakowska 2015; Urbanek 2018; Bieliński and Tomczyńska 2018; Ostrowicka and Stankiewicz 2018).

Some scientists are more consistently internationalized than others, and this distinction permeates Polish research. For internationalists, the international academic community is a reference group, while locals publish predominantly for the national academic community. Internationalization plays an increasingly stratifying role, as more international collaboration tends to mean higher publishing rates (and higher citation rates), and those who do not collaborate internationally are increasingly likely to lose out in terms of resources and prestige—a process referred to as "accumulative disadvantage" (Cole and Cole 1973: 146).

The present study addresses a number of research questions. What distinguishes internationalists from locals? Is there anything distinctive about internationalists in terms of who they are, how they work, or what they think about their academic work? In terms of research output, how productive are internationalists as compared with their local colleagues? What is the distribution of internationalists by academic field, position, age cohort, and gender? Are internationalists also more likely to collaborate domestically? What is the average distribution of working time and research role orientation among internationalists? What individual and/or institutional factors shape engagement in international research collaboration? In short, are internationalists a different species within the resource-poor Polish higher education system?

The paper is structured as follows: the next section presents the theoretical framework, followed by data and methods. The results section includes an overview of internationalists, patterns of individual research productivity and international collaboration, patterns of individual research productivity by publication type, a bivariate analysis of working time distribution and teaching and research role, and a multivariate analysis. The logistic regression analysis is in two parts; model approach (I) examines predictors of collaboration with international colleagues in research, and model approach (II) looks at how various aspects of internationalization influence research productivity. The paper ends with a summary of the findings, discussion and conclusions.

Theoretical framework

Studying international collaboration in research

Gouldner (1957) distinguished between scientists who are less research-oriented and more loyal to their employing organization (*locals*) and those who are less loyal to their organization and more research-oriented (*cosmopolitans*). Gouldner's pure types have subsequently been reformulated in both organizational studies and higher education research (Glaser 1963; Abrahamson 1965; Rhoades et al. 2008; Smeby and Gornitzka 2008). According to Robert K. Merton's sociology of science (Merton

1973: 374), outstanding scientists are more likely to be "cosmopolitans" oriented to wider "national and trans-national environments" while "locals" tend to be oriented "primarily to their immediate band of associates" or local peers. However, the distinction did not refer originally to internationalization but to organizational roles and professional identities and norms, with the concept of "mobility" at its center.

Gouldner contrasted immobile and institution-oriented scientists (loyal to inside reference groups) to mobile, cosmopolitan, career-oriented scientists (loyal to outside reference groups). According to Gouldner, professionals identify with their reference group and refer to it in making judgments about their own performance. In this regard, cosmopolitans and locals differ sharply in their attitude to research, their sources of recognition, and their academic career trajectories (Wagner and Leydesdorff 2005). In a study of Norwegian scientists, Kyvik and Larsen (1997: 261) related the local/cosmopolitan opposition to publishing modes rather than to international collaboration:

> while locals can be said to have the Norwegian scholarly community as a frame of reference, cosmopolitans take the values and standards of the international scientific community as a comparative frame of reference. Those who are locally oriented subsequently will tend to publish in Norwegian, while those who have a cosmopolitan attitude will be more inclined to compete for recognition in an international setting.

There is evidence that impediments to international research collaboration may include macro-level factors (geopolitics, history, language, cultural traditions, country size, country wealth, geographical distance); institutional factors (reputation; resources); and individual factors (predilections, attractiveness) (see Georghiou 1998; Hoekman, Frenken and Tijssen 2010; Luukkonen, Persson and Sivertsen 1992). In general, more productive scientists tend to collaborate more with international colleagues while the most productive or top performers are much more internationalized than their lower-performing colleagues (Kwiek 2019: 23–71). However, while research performance is directly correlated with intensity and propensity for international collaboration, the reverse correlation is not evident (Abramo, D'Angelo and Solazzi 2011).

International research collaboration is reported to have costs as well as benefits (Katz and Martin 1997; Jeong, Choi, and Kim 2014). According to Katz and Martin, "With more people and perhaps several institutions involved, greater effort is required to manage the research" (1997: 16). Specifically, transaction costs (Georghiou 1998) and coordination costs (Cummings and Kiesler 2007) are higher for international research collaboration. In collaborative research, there is a trade-off between increased publication and research funds and the need to minimize transaction costs (Landry and Amara 1998). Collaboration involving multiple universities complicates coordination and may undermine project outcomes (Cummings and Kiesler 2007). While research collaboration with highly productive scientists generally increases individual productivity, collaboration with low-productivity scientists is reported to have the opposite effect (Lee and Bozeman 2005).

As incentive and reward systems in European science evolve to become more output-oriented (Kyvik and Aksnes 2015; Kwiek 2019), individual scientists are under increasing pressure to cooperate and co-publish internationally. In general, multiple-institution papers are more highly cited than single-institution papers, and internationally co-authored papers are more highly cited than those with domestic co-authors (Narin and Whitlow 1990). Collaboration is increasing at author, institution, and country levels (Gazni, Sugimoto, and Didegah 2012), as performance-based funding and awareness of international research-based university rankings mean that scholarly publishing is closely linked to institutional and/or departmental funding.

At the same time, the Mertonian principle of priority of discovery suggests that international research collaboration is driven primarily by reward structures in highly competitive science systems, especially in the hard sciences (Kyvik and Larsen 1997). As Wagner and Leydesdorff (2005: 1616) have argued, "highly visible and productive researchers, able to choose, work with those who are more likely to enhance their productivity and credibility." Research collaboration at an individual level is reported to be ruled by researchers' "pragmatism" ("when there is something to gain, then a particular collaboration will occur, otherwise it will not") and by their "self-organization" (individual rather than institutional), determining "with whom to cooperate and under which forms" (Melin 2000: 39). According to Wagner and Leydesdorff, "The many individual choices of scientists to collaborate may be motivated by reward structures within science where co-authorships, citations and other forms of professional recognition lead to additional work and reputation in a virtuous circle" (2005: 1616).

International research collaboration can be viewed as an emergent, self-organizing, networked system, in which the selection of partners and research settings often relies on the researchers themselves. In more spontaneous or bottom-up collaborations, what matters is "the individual interests of researchers seeking resources and reputation" (Wagner and Leydesdorff 2005: 1616). Most research collaborations begin with face-to-face meetings, especially at conferences (Melin 2000). Scientists connect with each other "on a peer-to-peer level, and a process of preferential attachment selects specific individuals into an increasingly elite circle. The process reduces free riders and greatly increases the visibility of parts of the system" (Wagner 2018: x).

According to resource allocation theory, the attentional resources that scientists and their teams can invest in research in terms of their commitment and time are always limited. This theory holds that "the resources allocated to a function will decrease as resources allocated to other functions increase" (Jeong, Choi, and Kim 2014: 523). Consequently, the decision to engage in research teamwork "is ultimately a resource allocation decision by which members must decide how to best allocate their limited resources" (Porter, Itir Gogus, and Yu 2010: 241), as time is often a more valuable resource than research funding (Katz and Martin 1997). Additional requirements can reduce the available time and energy for actual research activities (Jeong, Choi, and Kim 2011). Collaboration also involves personal decisions based on "trust" and

"confidence" (Knorr Cetina 1999), as well as "purpose", involving multiple issues that range from "access to expertise" to "enhancing productivity" (Beaver 2001: 373).

For present purposes, following Katz and Martin (1997), international research collaboration at the individual level refers to collaboration between scientists located in different countries (rather than between scientists of different nationalities located in the same country or institution) while intra-national (or domestic) collaboration is understood as collaboration within a single country. However, as indicated in the findings, international collaboration rests on a much wider base of domestic activities (Georghiou 1998; Wagner 2006).

Collaboration is largely a matter of social convention among scientists and therefore difficult to define; what constitutes a collaboration varies across levels and changes over time (Katz and Martin 1997). Beyond "sole research" mode, it is important to distinguish clearly between "internal" collaboration (within the same organization), "domestic" collaboration (within the same country) and "international" collaboration (between countries) (Jeong, Choi, and Kim 2011: 969). In general, research collaboration can be defined as a "system of research activities by several actors related in a functional way and coordinated to attain a research goal corresponding with these actors" research goals or interests" (Laudel 2002: 5). In other words, collaboration presupposes a shared research goal, is defined by activities rather than by the actors involved, and refers only to research that includes personal interactions. On this definition, collaboration need not have any publication objective at any point (Sooryamoorthy 2014). However, as broader notions of collaboration are not easy to measure, many studies of research collaboration "begin and end with the co-authored publication" (Bozeman and Boardman 2014: 2–3).

International research collaboration can be said to have two prerequisites: the researcher's motivation and their attractiveness (as a researcher) to international colleagues (Kyvik and Larsen 1994; Wagner 2006). The potential to join international research networks depends on one's attractiveness as a research partner (Wagner and Leydesdorff 2005). In this regard, "Visibility is a basic condition for being potentially interesting to other scientists, but one also has to be attractive in order to be actively sought out by others" (Kyvik and Larsen 1994: 163). Availability of resources increases the level of international research collaboration (Kyvik and Larsen 1997; Jeong, Choi, and Kim 2014). Beyond that, scientists create and sustain the connections that form the global knowledge network largely because they "become resources to others … connections are retained as long as they are of mutual (or potential) interest to participating members" (Wagner 2018: 62). In short, networks mean (international) collaboration.

International research collaboration varies by academic generation as well as by country and discipline. Scientists entering universities in different eras encounter different career opportunities and academic norms (Stephan and Levin 1992). Changes in productivity and collaboration patterns across academic generations are in part explained by changing norms of appropriate academic behavior, in which international

collaboration figures prominently (Kyvik and Aksnes 2015). Although this cross-generational perspective complements traditional cross-national, cross-institutional, and cross-disciplinary perspectives, relatively few studies to date have attempted a cohort analysis of academic careers (see Marquina and Jones 2015; Shin, Arimoto, and Cummings 2014; Jung, Kooij, and Teichler 2014; Kwiek 2015c; Kwiek 2019).

As Kwiek (2019) has shown, a cross-generational European comparison reveals that the highest share of scientists collaborating with international research partners is found among the oldest generations. In the 11 countries studied, the share of internationally collaborating scientists was never highest for the youngest academic cohort. This is perhaps unsurprising, as international research collaboration needs time to develop as well as access to funding (Jeong, Choi, and Kim 2014). However, there were substantial cross-country differences, notably between Germany, Poland, and Portugal on the one hand and the Netherlands, Ireland, and the UK on the other. In the former group, the share of internationalists in the youngest generation was about 40-45%, rising to about 80% in the latter countries.

Understanding of international research collaboration depends predominantly on bibliometric studies. Based on a large-scale academic survey (N = 3,704 returned questionnaires) of Poland's resource-poor higher education system,[1] this study has global implications for academic career and productivity patterns and contributes to better understanding "the collaborative era in science" (Wagner 2018) by contrasting the prototypical figure of the internationalist with the local research scientist.

Research hypotheses

Nine working hypotheses were tested in this study.

H1: *Gender hypothesis*: Internationalists tend to be male rather than female.
H2: *Age and academic seniority hypothesis*: Internationalists tend to be older and occupy higher academic positions.
H3: *Academic field distribution hypothesis*: Internationalists tend to come from hard rather than soft science fields.
H4: *Domestic collaboration hypothesis*: Internationalists tend to collaborate domestically more often than locals.
H5: *Productivity hypothesis*: Internationalists are more productive than locals.
H6: *Working time distribution hypothesis*: On average, internationalists work longer hours and spend more time on research, less time on teaching, and more time on administration.

[1] According to *Main Science and Technology Indicators* (OECD 2019), Poland's Gross Domestic Expenditure on R&D (GERD) as a percentage of Gross Domestic Product (GDP) in 2015 was the second-lowest in the European Union at 1.00 (as compared to 1.96 for EU-28 countries, 2.10 for EU-15 countries, and 2.38 for OECD countries). Additionally, Poland's Higher Education Expenditure on R&D (HERD) as a percentage of Gross Domestic Product (GDP) was the third-lowest in the European Union in 2015 at 0.29 (as compared to 0.45 for EU-28 countries, 0.48 for EU-15 countries, and 0.42 for OECD countries).

H7: *Academic role orientation hypothesis*: Internationalists are more research-oriented than locals.
H8: *Individual predictors hypothesis*: Individual predictors of being an internationalist are more important than institutional predictors.
H9: *Productivity type hypothesis*: Dimensions of internationalization differ in their impact on different productivity measures.

Data and methods

Defining internationalists

Internationalists in Polish universities are clearly defined as academic scientists who *collaborate* in *research* with their *international* colleagues. Collaborating with international research colleagues may indicate different levels of international mobility and co-authorship (from intense to none). For present purposes, internationalists are contrasted with *locals*—academic scientists who do not collaborate with international research colleagues. In the survey, the questions pertaining to international research collaboration were formulated as follows. "How would you characterize your research efforts during this (or the previous) academic year? Do you collaborate with international colleagues?" (Yes/No) (Question D1/4). No explanation or guidance was provided in relation to the terms *collaborate, international*, or *research*.

Dataset

The data were sourced from the European Academic Profession: Responses to Societal Challenges (EUROAC) study, which is a sister project of the global Changing Academic Profession (CAP) study (see Carvalho 2017 for a recent overview of the CAP/EUROAC family). The final dataset, dated June 17 2011, was created by René Kooij and Florian Löwenstein from the International Centre of Higher Education and Research—INCHER-Kassel. The response rate in Poland (11.22%) was similar to those in studies of the academic profession in several countries over the last decade, including the Netherlands (18%) (de Weert and van der Kaap 2014: 121); Canada (17%) (Jones et al. 2014: 348); the United Kingdom (15%) (Locke and Benion 2011: 178); Hong Kong (13%) (Rostan et al. 2014: 25); the Republic of Korea (13%) (Shin et al. 2014: 183); and in Croatia, Austria, Switzerland, and Portugal (10% or less) (Teichler and Höhle 2013: 8).

In the Polish classification, scientists were grouped in eight fields or clusters of academic disciplines that best represent the current structure of the Polish academic profession: humanities and arts, social sciences, physical sciences and mathematics, life sciences, engineering and technical sciences, agriculture, medical sciences and health-related sciences, and other disciplines (e.g., fine arts).

The total number of valid responses (those answering at least 50% of questionnaire items) was 3,704; non-responses occurred at both item and unit (person) level, and

item non-responses differed significantly. As the final analysis excluded scientists from "other" disciplines, those employed in the postdoctoral position of *docent*, those who did not answer the question about international collaboration in research, and those whose work contract did not involve research, 2,453 observations from seven major discipline clusters were included: 1,172 from internationalists (51.4%) and 1,107 from locals (48.6%).

Table 1 Distribution of the sample population. Internationalists = scientists collaborating internationally in research (Yes). Only scientists employed full-time in the university sector and involved in both teaching and research were included. (This applies to all figures and tables.)

	All (n)	**Research-involved (n_{RI})**	**% Research-involved**	**Internationalists (INT) (n_I)**	**Locals (LOC) (n_L)**	**Internationalists (INT) % (n_I): (n_L+n_I)**	**Locals (LOC) % (n_L): (n_L+n_I)**
HUM	566	561	99.1	251	271	48.1	51.9
SOC	263	257	97.9	86	151	36.3	63.7
PHYSMATH	191	190	99.7	144	39	78.7	21.3
LIFE	417	415	99.5	256	148	63.4	36.6
ENGITECH	557	554	99.5	256	264	49.2	50.8
AGRICULT	176	174	99.3	62	95	39.5	60.5
MEDHEALTH	284	279	98.3	117	139	45.7	54.3
Total	2,453	2,430	99.1	1,172	1,107	51.4	48.6
Soft combined	829	818	98.7	337	422	44.4	55.6
Hard combined	1,624	1,612	99.3	835	685	54.9	45.1

Sampling

Stratified random sampling was used to ensure that the resulting sample was distributed in the same way as the target population (Hibberts et al. 2012: 61–62; Bryman 2012: 192–193). A stratified sampling frame was created, using two criteria: gender and academic position. (The description of sampling, instrument, data collection, and limitations draw on a parallel *Scientometrics* paper on Polish top performers; Kwiek 2018c: 421–425.) Stratification of the sample mirrored that of the population on the specified criteria and mirrored a simple random sample in all other ways. Random sampling was subsequently used to obtain elements from each stratum. Members of the target population were identified by accessing a national ministerial database of all Polish academic scientists.

At the time of the survey, the target population to which the results were to be generalized included 83,015 scientists employed full-time in the public sector (43.8% female and 56.2% male, including 17,683 full and associate professors (21.3%), 36,616 assistant professors (44.1%), 10,784 assistants (13.0%), and 15,013 senior lecturers and lecturers (18.1%) (GUS 2011: 308–309). Private sector scientists were excluded because the sector is fully teaching-focused.

The sample of Polish scientists was representative of the target population on the two strata of gender and academic rank and included 45.2% female scientists and 54.8% males; 22.6% full and associate professors, 42.1% assistant professors, 10.9%

assistants, and 24.4% senior lecturers and lecturers. There was no sampling bias; no members of the sampling frame had nil or limited chances of inclusion in the sample; and no group of scientists was systematically excluded from the sampling frame (Bryman 2012: 187). However, as it is impossible to determine to what extent the pool of respondents differed from the pool of non-respondents, there remains a possibility of non-response bias (Stoop 2012: 122), and no subsequent survey was conducted to ask non-responders why they did not participate. Non-response bias can occur where certain groups of respondents fail to respond or are less likely than others to participate in the survey or to answer certain survey questions (Hibberts et al 2012: 72), or when survey participation is correlated with survey variables (Groves 2006). However, non-response bias is only indirectly related to non-response rates; a key parameter is "how strongly correlated the survey variable of interest is with response propensity, the likelihood of responding" (Groves 2006: 670).

Instrument and data collection

The survey was performed by the National Information Processing Institute (OPI). An invitation to participate in the web-based survey, with individually coded identifier, was sent in June 2010 to 33,000 scientists—that is, all scientists whose e-mail addresses were available—at national level. This narrowed the target population to the sampling frame, with an inevitable coverage error. There was no pre-notification e-mail, and two reminders were sent electronically between June 1, 2010 and July 20, 2010. Full anonymity was assured in the invitation, and reminders were sent only to non-respondents, using the assigned identifiers. Web-based surveys tend to incur a specific non-response bias due to lack of internet access (although this is likely to be smaller for academics, who routinely use both e-mail and internet). The questionnaire was pilot tested by outside parties, who reviewed the format and wording and structure of individual items, in May 2010.

In seeking to contrast research internationalists and locals, there is a trade-off between the advantages of using self-reported survey data and publication numbers as the only measure of research performance and the use of a combination of publications, citations, H-index, and other bibliometric measures. Detailed individual-level data—including data on international research collaboration rather than the international publication co-authorship proxy—depend on the use of a survey instrument.
Use of the survey methodology raises an important issue: misreporting of self-reported publication data. This is predominantly associated with sensitive topics, where survey respondents may choose to answer dishonestly "due to a desire to present themselves in the best light to the interviewer or to avoid potential repercussions" (McNeeley 2012: 382). Overreporting socially desirable behavior in academia (e.g., increasing publication numbers) and underreporting socially undesirable behavior (e.g., non-publishing) may be an issue (de Vaus 1985), and some level of misreporting is inevitable. However, Polish scientists seem to have accurately reported publication data; based on publicly available institutional-level and faculty-level productivity data by institutional type, average responses matched expectations, which suggests that respondents did not view the questionnaire as sensitive. For instance, average

individual publishing rates corresponded to six major institutional types, with the highest rates for "universities" and "technical universities", and the lowest for "academies" and "higher vocational institutions." The observed high percentages of non-publishers and non-publishers in English suggest that misreporting was not a significant issue.

Methodological strengths and limitations

The analyses are based on self-declared data, provided voluntarily by Polish scientists. The chosen measure of research productivity was the number of peer-reviewed articles and peer-reviewed article equivalents published during a three-year reference period. To varying degrees, respondents "may present an untrue picture to the researcher, for example answering what they would like a situation to be rather than what the actual situation is" (Cohen et al. 2011: 404). Although self-reported publication data are not perfect, they do not seem to entail systematic error (that is, errors are random) or systematic bias (which occurs when errors tend to be in one direction more than another; see Spector 1981: 13). The survey instrument did not distinguish between different tiers of academic journals and did not permit study of citation patterns. Journal impact factor and number of author citations were beyond the scope of this survey. As a consequence of data anonymization, individual research productivity could not be linked to individual institutions beyond the six major institutional types.

To strengthen the robustness of the analyses (see also Kwiek 2018c, 2019), three measures were used in addition to peer-reviewed articles (PRA): peer-reviewed article equivalents (PRAE), internationally co-authored peer-reviewed article equivalents (IC-PRAE), and English language peer-reviewed article equivalents (ENG-PRAE). That is, publication counts were converted into article equivalents. The PRAE measure is calculated as the weighted sum of self-reported articles in books or journals (valued as 1 article equivalent), edited books (valued as 2 article equivalents), and authored books (valued as 5 article equivalents) published over the three-year reference period. This follows the procedure used in Piro et al. (2013: 309), Røstad and Aksnes (2015: 319) Bentley (2015: 870), and Gorelova and Lovakov (2016: 11). In most survey-based studies, 4–6 articles equate to one full monograph.

Following Bentley (2015), a self-reported share of peer-reviewed publications was applied to each observation. The advantage of using the PRAE measure in a cross-disciplinary study is that it captures various publishing outlets, encompassing authored and edited books (which are still a major social sciences and humanities outlet in Poland) as well as articles. The IC-PRAE measure is based on the self-reported share of publications co-authored with international colleagues, and the ENG-PRAE measure is based on the self-reported share of publications published in a foreign language, which is predominantly English (for 87.1% of Polish scientists). The survey therefore asked combined questions about number of scholarly contributions and percentage of peer-reviewed publications, English-language publications, and internationally co-authored publications.

The research productivity analyses reported below convert publication counts into article equivalents for fairer comparison of productivity across academic fields in which publication patterns are dissimilar (Kyvik and Aksnes 2015). The PRAE measure was used to facilitate more comprehensive exploration of cross-disciplinary differences in publication patterns between top performers and others; the IC-PRAE and ENG-PRAE measures were used to explore how the two groups differed in terms of internationalization. Article equivalents were applied to multi-disciplinary studies involving major clusters of disciplines rather than to science, technology, engineering, and mathematics clusters alone. This approach follows Ramsden (1994: 213); Guldbrandsen and Smeby (2005: 938); Kyvik and Aksnes (2015: 1441); Villanueva-Felez et al. (2013: 472); Piro et al. (2013: 309); Teichler et al. (2013: 146-147); and Arimoto (2011: 296). Article equivalents have also been used in *Scientometrics* and *Journal of Informetrics* studies (e.g., Kyvik 1989: 206; Piro et al. 2016: 945; Bentley 2015: 870; Røstad and Aksnes 2015: 319). The use of PRA and PRAE measures reflects the particularity of the Polish system, which has traditionally supported the production of books across all academic fields.

Other limitations

One of the present study's limitations is that the survey instrument could not distinguish different nationalities (countries), locations (institutions and departments), intensities (high to low), and modes of contact (e.g., face-to-face/conference/e-mail) in international research collaboration. Instead, international research collaboration as a behavioral concept was measured as a crude *Yes* or *No*, and different individual perceptions of internationalization in research were amalgamated and averaged. A second limitation is that Polish scientists could not be compared across institutions—for example, the study does not illuminate differences between scientists from prestigious institutions (especially the flagship institutions, the University of Warsaw and Jagiellonian University; see Kwiek and Szadkowski 2018) and those of lower academic standing. A further limitation relates to the structure of the dataset; as no distinction could be drawn between single-author and multiple-author publications only total counts were possible. The same was true of national and international publications, beyond the use of proxies ("internationally co-authored publications" and "publications in English"). Finally, the cross-sectional dataset made it impossible to compare research internationalization across academic generations. Despite these limitations, it was possible to test the working hypotheses and to arrive at valid conclusions.

Research results

Internationalists: an overview

H1: Gender hypothesis: Internationalists tend to be male rather than female.

Frequencies of the selected demographic characteristics of internationalists are listed in Table 2. Unsurprisingly (in light of existing evidence on gender in international research collaboration) (Ackers 2008; Fox et al. 2016; Abramo, D'Angelo, and Murgia 2013), male scientists are more internationalized than female scientists; a majority of male scientists (56.0%) are internationalists as compared to 45.0% of females. Gender differences are field-sensitive, with a higher percentage of female internationalists in hard academic fields. As the gender difference is statistically significant and has powerful policy implications in terms of internationalization as a stratifying force in the academic profession, Hypothesis 1 is supported.

Table 2. Sample description: frequencies of selected demographic characteristics

		Internationalists (INT)		**Locals (LOC)**		**Total**	
		N = 1,151		**N = 1,090**		**N = 2,241**	
		N	**%**	**N**	**%**	**N**	**%**
Gender	Male	722	56.0*	566	44	1288	57.5
	Female	429	45	524	55.0*	953	42.5
Age group	under 30	21	56.1	17	43.9	38	1.7
	30 to 39	368	45.4	443	54.6*	812	36.1
	40 to 49	273	48.1	294	51.9	566	25.1
	50 to 59	262	59.9*	175	40.1	437	19.4
	60 and more	232	58.3*	167	41.7	399	17.7
Academic experience	under 10	300	47.9	326	52.1*	627	27.7
	10 to 19	280	43.8	359	56.2*	640	28.3
	20 to 29	221	57.2*	165	42.8	386	17.1
	30 to 39	255	57.6*	188	42.4	443	19.6
	40 and more	107	64.6*	59	35.4	166	7.3
Academic field	HUM	251	48.1	271	51.9	522	22.9
	SOC	86	36.3	151	63.7*	238	10.4
	PHYSMATH	144	78.6*	39	21.4	183	8
	LIFE	256	63.3*	148	36.7	404	17.7
	ENGITECH	256	49.3	264	50.7	519	22.8
	AGRICULT	62	39.5	95	60.5*	157	6.9
	MEDHEALTH	117	45.7	139	54.3*	256	11.2
Soft/Hard	SOFT	337	44.4	422	55.6*	759	33.3
	HARD	835	54.9*	685	45.1	1520	66.7
Academic degree	MA/MSc	33	47.3	37	52.7	70	3.2
	PhD	585	43.2	769	56.8*	1354	61.5
	Habilitation degree	267	59.0*	186	41	452	20.5
	Professorship title	240	73.8*	85	26.2	326	14.8
Marital status	Married/in partnership	975	51.7	912	48.3	1887	83.8
	Single	181	49.6	184	50.4	365	16.2
Academic position	Instructor (Asystent)	133	42.6	179	57.4*	311	13.6
	Assistant prof. (Adiunkt)	577	45.2	698	54.8*	1274	55.9
	Associate prof. (Prof. ndzw.)	275	62.3*	167	37.7	442	19.4

	Full professor (Profesor zw.)	188	74.6*	64	25.4	252	11.1
Age	Mean	1156	47.5*	1095	45	2251	46.3
Academic experience 1)	Mean	1164	20.9*	1098	18	2262	19.5
Institutional experience 2)	Mean	1158	18.6*	1089	16.1	2247	17.4

1) *Academic experience* refers to number of years since first full-time job (other than research and teaching assistant in the higher education/research sector; Question A6). 2) *Institutional experience* refers to number of years spent at current institution. *p < 0.05

H2: Age and seniority hypothesis: Internationalists tend to be older and occupy higher academic positions.

Internationalization in research is an older scientist's game, increasing with age, academic experience, academic degree, and academic position (Table 2). First, internationalization clearly increases with age; internationalists are a minority in the 30–39 age group but a majority in older age brackets. Second, internationalization clearly increases with academic experience; while a minority of scientists with less than 20 years of experience are internationalists, a majority of those with at least 20 years of experience are internationalists, with the highest share in the oldest age group. (Academic experience refers to years of full-time employment in the higher education sector beyond teaching and/or working as a research assistant.) Finally, internationalization increases with academic degree level and academic position; a minority of PhD-only scientists and assistant professors (where a PhD is prerequisite for habilitation and habilitation is prerequisite for professorship) are internationalists as compared to two-thirds of scientists with professorships and those employed as ordinary professors. In this sample, the mean age of internationalists was 47.5 years, and their mean academic experience and institutional experience (i.e., employment by the same institution) were 20.9 years and 18.6 years, respectively.

Polish internationalists therefore align with known patterns (Rostan and Ceravolo 2015; Rostan, Ceravolo, and Metcalfe 2015; Shin, Jung, and Kim 2014); in general, internationalization is lower among younger generations and higher among older generations. Across all age brackets, the highest levels are in the physical sciences and mathematics, and the lowest are in social sciences (Kyvik and Larsen 1997; Smeby and Gornitzka 2008) (see Fig. 1). The distribution of Polish scientists across academic clusters corresponds roughly to their distribution in the higher education system. (The tiny Polish Academy of Science was excluded from this survey.) The share of internationalists increases with academic position across all disciplines, both hard and soft. For PhDs in SOC, AGRICULT and MEDHEALTH, the figure is about one-third as compared to two-thirds in PHYSMATH. For habilitation degree holders, the share is lowest in AGRICULT and SOC and highest in PHYSMATH and LIFE. Finally, in the case of professors, eight or nine out of ten in PHYSMATH, LIFE and MEDHEALT are internationalists as compared to about half in SOC and AGRICULT (see Fig. 2). On that basis, Hypothesis 2 is supported.

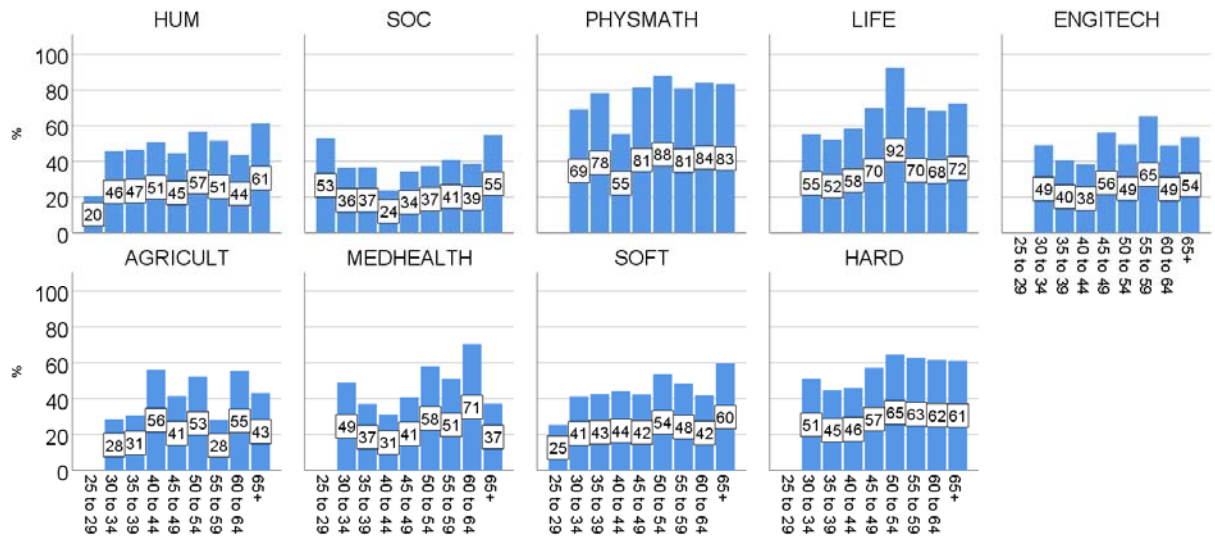

Fig. 1. Internationalists by age group and academic cluster (%).

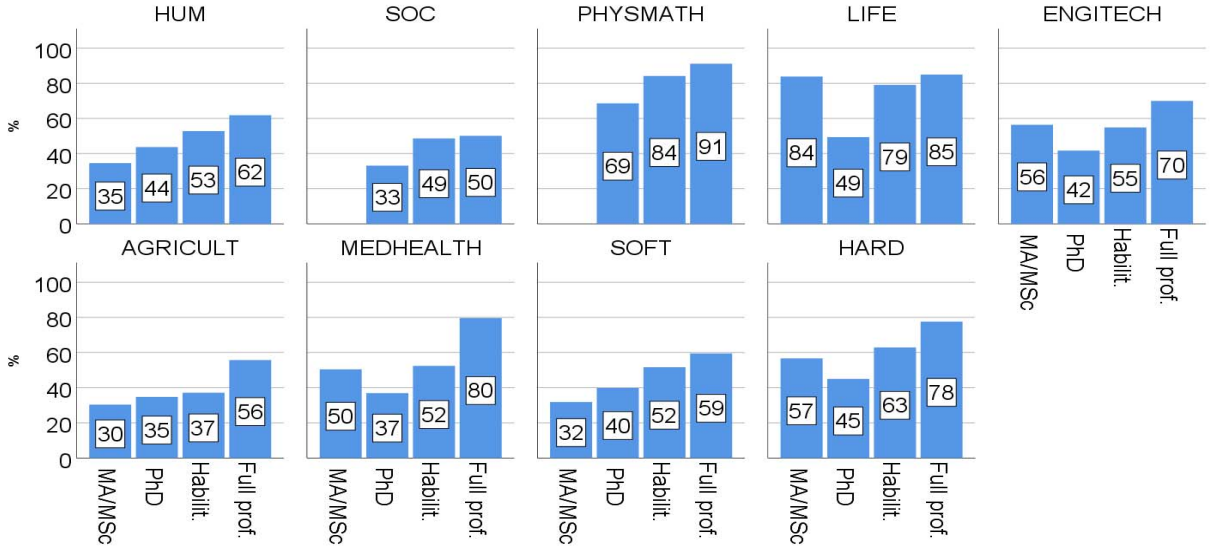

Fig. 2. Internationalists by academic degree and academic cluster (%)**.**

H3: Academic field distribution hypothesis: Internationalists tend to come from hard rather than soft science fields.

The cluster of soft academic fields comprises HUM and SOC while the cluster of hard academic fields comprises PHYSMATH, LIFE, ENGITECH, AGRICULT, and MEDHEALTH. All OTHER fields were removed from the analysis. Internationalization is highly field-sensitive; internationalists comprise only a third of scientists in social sciences but more than three quarters in physical sciences and mathematics. As they constitute a minority in soft fields and a majority in hard fields (Table 3), Hypothesis 3 is supported.

Table 3. Scientists reporting collaboration with international colleagues (D1/4) by academic cluster (%)

	Yes - Internationalists	No - Locals	Total
HUM	48.1	51.9	100
SOC	36.3	63.7***	100
PHYSMATH	78.6***	21.4	100
LIFE	63.3***	36.7	100
ENGITECH	49.3	50.7	100
AGRICULT	39.5	60.5*	100
MEDHEALTH	45.7	54.3*	100
Total	51.4**	48.6	100
Soft combined	44.4	55.6***	100
Hard combined	54.9***	45.1	100

*p < 0.05; **p < 0.01; ***p < 0.001

H4: Domestic collaboration hypothesis: Internationalists tend to collaborate domestically more often than locals.

Polish internationalists also collaborate more often domestically—in other words, international collaboration seems not to exclude collaboration with national peers (D1/3: "Do you collaborate with persons at other institutions in your country?"). Only one in five internationalists (20.5%) do not collaborate domestically (Table 4). We can only speculate about the reasons for domestic non-collaboration, which may include lack of time for both types of collaboration, lack of funding for domestic collaboration, lower quality of national peers, or limited opportunities to co-publish internationally. Interestingly, only half of locals collaborate domestically—in other words, half of those who do not collaborate internationally also fail to collaborate domestically. This effect is highly differentiated across fields; about two-thirds of locals in humanities and social sciences do not collaborate domestically—in other words, in soft academic disciplines, the "lonely scholar" model prevails (63.3% of locals). The highest share of locals collaborating domestically is in life sciences (71.6%).

Table 4. Scientists reporting domestic collaboration (D1/3) by academic cluster (%)

	Internationalists (INT)		Locals (LOC)	
	Collaborate domestically	Do not collaborate domestically	Collaborate domestically	Do not collaborate domestically
HUM	72.1***	27.9	36.9	63.1***
SOC	75.5	24.5	36.5	63.5***
PHYSMATH	74.0	26.0	46.7	53.3
LIFE	86.7***	13.3	71.6***	28.4
ENGITECH	78.2	21.8	56.8*	43.2
AGRICULT	91.7*	8.3	59.8*	40.2
MEDHEALTH	85.6	14.4	48.6	51.4

Total	79.5	20.5	50.0	50.0
Soft combined	73.0***	27.0	36.7	63.3***
Hard combined	82.1***	17.9	58.2***	41.8

*p < 0.05; **p < 0.01; ***p < 0.001

For all academic fields (Table 5), the percentage of internationalists collaborating domestically is higher than the percentage of locals collaborating domestically. As the results are statistically significant for all fields except social sciences and agriculture, Hypothesis 4 is supported.

Table 5. National research collaboration: scientists collaborating domestically in research by academic cluster: INT vs. LOC (%)

	All collaborating domestically (ALL) %	**Internationalists collaborating domestically (INT)** %	**Locals collaborating domestically (LOC)** %	**Z**	**p-value**	**Significantly higher percentage**
HUM	54.4	63.9	36.1	6.530	0.006	INT
SOC	51.3	53.5	46.5	1.066	0.227	--
PHYSMATH	68.1	85.2	14.8	11.076	<0.001	INT
LIFE	81.3	67.4	32.6	8.877	0.002	INT
ENGITECH	67.9	56.8	43.2	3.560	0.036	INT
AGRICULT	73.2	50.0	50.0	0.006	0.994	--
MEDHEALTH	66.8	59.7	40.3	3.550	0.036	INT
Soft	53.4	60.8	39.2	6.047	0.008	INT
Hard	71.8	63.0	37.0	12.055	<0.001	INT
Total	65.8	62.4	37.6	13.444	<0.001	INT

Individual research productivity and international collaboration

H5: Productivity hypothesis: Internationalists are more productive than locals.

This hypothesis was tested using the standard measure of number of peer-review articles (PRA) and IC-PRA and ENG-PRA measures to provide a more detailed account. Average research productivity is summarized in Tables 6–8, comparing locals (left panel) and internationalists (right panel), by productivity type (PRA, IC-PRA, ENG-PRA) and academic cluster. The present study adopts Teodorescu's (2000: 206) definition of research productivity as the "self-reported number of journal articles and chapters in academic books that the respondent had published in the three years prior to the survey." For instance, in line 1, mean PRA for the three-year reference period is 3.2 for all locals and 4.3 for all internationalists in humanities (HUM) cluster; as only 58.3% of locals and 56.9% of internationalists actually published, the means are 5.4 and 6.5, respectively, with medians of 3.6 and 6.1, respectively. The 95% confidence interval for mean (4.6 articles as a lower bound and 6.2 articles as an upper bound) indicates that the 4.6-6.2 interval covers the number of articles with 95 percent of certainty; similarly internationalists in the humanities produced on average 6.5 articles, with the 5.3-8.5 interval. In the European context, the average Polish scientist is a low

research performer, and their publication outlets are largely national (Kwiek 2015b; Kwiek 2016b).

As shown in Table 7, international co-authorship of publications is marginal for Polish locals (2.1%) and higher (but still relatively low) for internationalists (13.8%). There is clear cross-disciplinary differentiation among internationalists; for PHYSMATH, the share is almost 50%, and for LIFE and AGRICULT, it is about 40%. At the other end of the spectrum, humanities and social sciences internationalists fall in the 15–20% range. The average for soft academic fields is 15.0% while hard fields average 37.6%.

Finally, as shown in Table 8, about a third of Polish locals publish in English (36.3%), as compared to 51.7% of those collaborating internationally. Again, the highest shares are reported for PHYSMATH, with six out of ten (locals and internationalists) publishing in English. In general, Polish internationalists are a world apart from locals in terms of publishing patterns. Additionally, internationalists are strongly differentiated by academic discipline and in particular by the soft/hard split.

Interestingly, the percentage of IC-PRA in the PRA pool for internationalists is generally much higher in all clusters other than ENGITECH (see Fig. 3). Internationalists produce more publications and more publications with international colleagues, but there are significant disciplinary variations. Among internationalists in the PHYSMATH cluster, almost 70% of publications are internationally co-authored; in MEDHEALTH and LIFE clusters, the figure is about 50% while in the HUM and SOC clusters, it is just above 30%.

Table 6. Dimensions of research productivity (internationalists vs. locals): peer-reviewed articles (**PRA**) published in the three-year reference period

	Locals (LOC)								Internationalists (INT)							
	Mean	% publishers	Mean (publishers)	95% CI – LB	95% CI - UB	Median	SD	N	Mean	% publishers	Mean (publishers)	95% CI – LB	95% CI – UB	Median	SD	N
HUM	3.2	58.3	5.4	4.6	6.2	3.6	5	158	4.3	56.9	6.5	8.5	5.3	6.1	7.5	142
SOC	4.0	56.9	7	5.8	8.2	6	5.6	86	4.4	52.7	6.3	10.5	6	7.1	8.4	46
PHYSMATH	2.5	61.0	4	2.4	5.7	3	4	24	5.4	61.0	7.6	10.1	8	5.9	8.9	88
LIFE	2.5	42.8	5.9	4.4	7.3	4	5.8	63	5.0	51.6	8.4	10.9	8	7.2	9.7	132
ENGITECH	2.8	41.4	6.7	5.4	8.1	4.2	7.1	109	4.9	57.9	7.2	9.5	7	7	8.4	148
AGRICULT	3.2	50.5	6.4	4.7	8.2	6	6	48	4.6	53.9	6.2	10.8	6.5	6.5	8.5	34
MEDHEALTH	2.8	38.4	7.3	5.5	9.1	4.5	6.7	54	4.9	55.9	6.8	10.7	5	7.9	8.8	65
SOFT combined	3.5	57.8	6	5.3	6.7	4.4	5.3	244	4.3	55.8	6.8	8.6	5.4	6.3	7.7	188
HARD combined	2.8	43.5	6.4	5.7	7.1	4	6.4	298	5.0	55.9	8.3	9.5	7	7	8.9	467
Total	3.0	48.9	6.2	5.7	6.7	4	5.9	542	4.8	55.9	8	9.1	7	6.8	8.6	654

Table 7. Dimensions of research productivity (internationalists vs. locals): internationally co-authored peer-reviewed articles (**IC-PRA**) published in the three-year reference period

	Locals (LOC)								Internationalists (INT)							
	Mean	% internat. co-authoring	Mean (publishers only)	95% CI – LB	95% CI - UB	Median	SD	N	Mean	% internat. co-authoring	Mean (publishers only)	95% CI – LB	95% CI – UB	Median	SD	N
HUM	0.02	2.1	1.2	0.5	1.8	1.1	0.6	6	0.3	13.8	2.0	0.7	3.3	1.1	3.7	35
SOC	0.01	1.5	0.3	-4.4	5.1	0.2	0.5	2	0.3	18.5	1.8	0.8	2.8	1.2	1.9	16
PHYSMATH	0.02	1.8	1.1	.	.	1.1	.	1	2.5	47.4	5.3	4.1	6.5	3.7	4.8	68
LIFE	0.08	4.5	1.8	0.5	3.1	1.2	1.4	7	1.9	37.6	4.9	3.7	6.1	2.8	6.0	96
ENGITECH	0.09	3.2	2.9	-0.5	6.3	0.9	4.0	8	1.0	34.5	2.8	2.0	3.6	1.5	3.6	88
AGRICULT	0.02	3.5	0.7	-0.8	2.2	0.6	0.6	3	0.8	38.6	2.1	1.2	3.1	1.4	2.3	24
MEDHEALTH	0.03	2.1	1.6	-2.4	5.6	1.8	1.6	3	1.1	31.7	3.5	2.0	5.0	1.2	4.5	37
SOFT combined	0.02	1.9	0.9	0.4	1.5	0.9	0.7	8	0.3	15.0	1.9	1.0	2.8	1.1	3.2	51
HARD combined	0.06	3.2	2.0	0.8	3.2	1.1	2.7	22	1.5	37.6	4.0	3.5	4.6	2.1	4.9	314
Total	0.05	2.7	1.7	0.8	2.6	1.0	2.4	30	1.2	31.1	3.7	3.3	4.2	2.0	4.7	364

Table 8. Dimensions of research productivity (internationalists vs. locals): English language peer-reviewed articles (**ENG-PRA**) published in the three-year reference period

	Locals (LOC)								Internationalists (INT)							
	Mean	% publishing in English	Mean (publishers only)	95% CI – LB	95% CI – UB	Median	SD	N	Mean	% publish. in English	Mean (publishers only)	95% CI – LB	95% CI – UB	Median	SD	N
HUM	0.5	31.3	1.5	1.1	1.9	0.8	1.8	85	1.3	46.1	2.8	2.2	3.4	1.6	3.2	115
SOC	0.5	36.6	1.3	0.7	1.8	0.6	2.0	55	1.4	46.1	3.0	1.7	4.3	1.2	4.1	40
PHYSMATH	2.3	59.2	3.9	2.2	5.5	3.0	3.8	23	5.2	60.6	8.6	7.3	9.8	7.0	5.9	87
LIFE	1.8	39.7	4.4	3.3	5.5	3.0	4.2	59	4.2	51.0	8.3	7.1	9.5	6.0	7.1	130
ENGITECH	1.4	34.8	4.1	3.1	5.2	2.3	5.2	92	3.5	55.4	6.2	5.3	7.2	4.9	5.8	142
AGRICULT	1.6	45.2	3.6	2.5	4.8	2.4	3.7	43	2.7	53.0	5.1	3.5	6.7	3.5	4.6	33
MEDHEALTH	1.1	32.5	3.2	2.1	4.4	1.5	3.8	45	3.2	49.4	6.5	4.9	8.2	4.5	6.3	58
SOFT combined	0.5	33.2	1.4	1.1	1.7	0.8	1.9	140	1.3	46.1	2.8	2.3	3.4	1.5	3.4	155
HARD combined	1.5	38.2	3.9	3.4	4.5	2.4	4.4	262	3.9	53.9	7.2	6.6	7.8	5.6	6.3	450
Total	1.1	36.3	3.1	2.7	3.4	1.8	3.9	402	3.2	51.7	6.1	5.6	6.6	4.1	6.0	605

Across academic clusters, internationalists (accounting for 51.4% of all scientists) produce more than 90% of internationally co-authored publications (Table 9); in PHYSMATH, SOC and LIFE clusters, the share is 97–99.9 percent. This means that scientists in these clusters who collaborate internationally produce almost all internationally co-authored publications—that is, no international collaboration means no internationally co-authored publications.

Internationalists are also responsible for 75.0% of all Polish publications in English ENG-PRA. In PHYSMATH and LIFE, they are responsible for more than 80% of publications in English. Locals (about half of the Polish academic profession) produce only a quarter of all publications in English. In other words, non-collaboration is strongly correlated with publishing in Polish only.

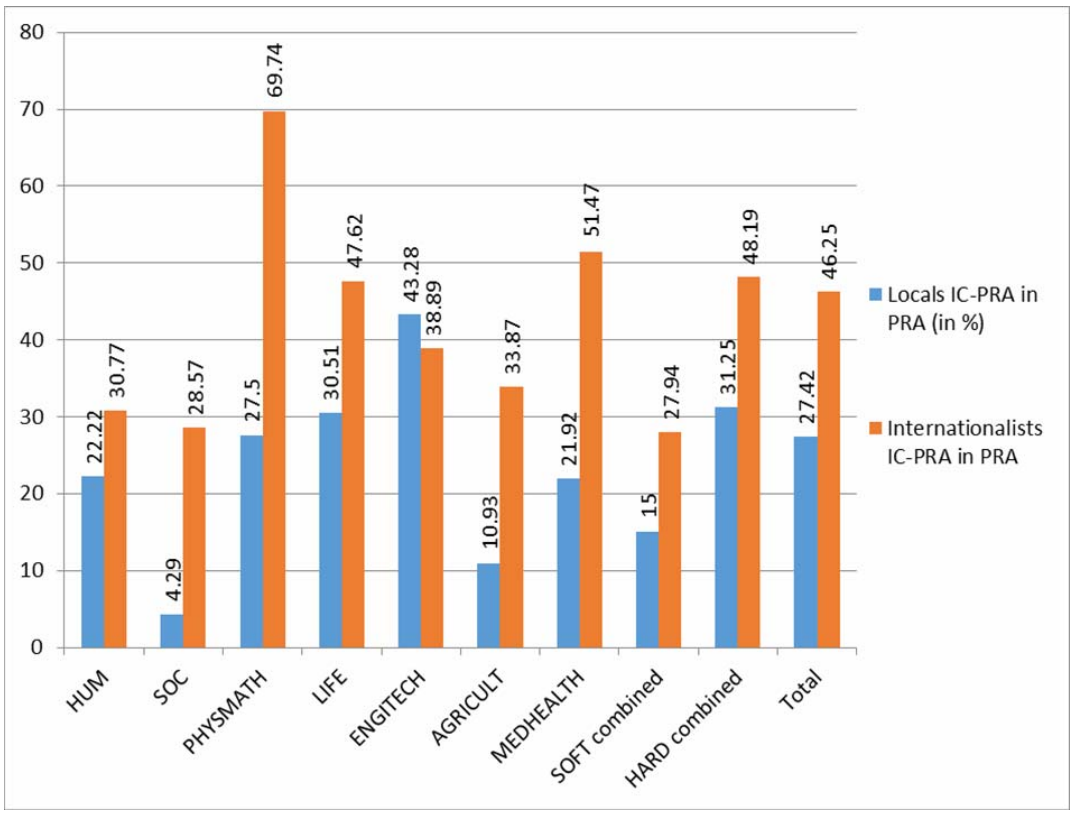

Fig. 3. Research productivity by academic cluster: internationalists (INT) vs. locals (LOC). Percentage of IC-PRA in PRA: internationally co-authored peer-reviewed articles and article equivalents in the peer-reviewed articles and article equivalents published in the three-year reference period. The results are statistically significant for all clusters.

Table 9. Average research output of Polish internationalists as a share of total research output, by cluster of academic disciplines, by productivity category (IC-PRA and ENG-PRA) (in percentage).

Academic cluster	INT (%)	IC-PRA	ENG-PRA
HUM	48.1	91.1	71.6
SOC	36.3	97.4	62.8
PHYSMATH	78.6	99.8	89.3
LIFE	63.3	97.6	80.6
ENGITECH	49.3	91.1	69.9
AGRICULT	39.5	95.6	51.9
MEDHEALTH	45.7	96.6	72.0
Total (mean)	51.4	96.4	75.0
SOFT combined	44.4	92.8	69.0
HARD combined	54.9	96.6	75.9

Research productivity among Polish scientists is strongly correlated with international research collaboration and is consistently higher than that of Polish scientists who are not involved in international collaboration across all academic clusters and on all measures applied. International publication co-authorship is also strongly correlated with international research collaboration, ranging from 1.2 times higher than for locals (MEDHEALTH) to 5 times higher in the physical sciences and mathematics and social sciences clusters. In contrast, scientists who do *not* collaborate internationally report a mere 3.2% of their publications as internationally co-authored in hard science fields and no more than 1.9% in soft fields (Table 9). The policy lesson is simple: "no international collaboration, no international co-authorship" (which aligns with the findings in Kwiek 2018b).

The pattern is consistent for all scientists (internationalist and local) across all academic clusters, both in Poland and across European systems. Among those who do not collaborate internationally, only a marginal percentage of their publications are co-authored with colleagues from other countries. These scientists account for a substantial share of the academic profession across Europe, including 47.5% in the professions, 40.0% in engineering 31.9% in humanities and social sciences, 39.6% in life and medical sciences, and 25.3% in physical sciences and mathematics (based on a sample of 17,211 scientists from 11 systems; Kwiek 2019: 143).

Individual research productivity by publication type

Individual research productivity can also be examined by publication type beyond peer-reviewed articles (see for example Sooryamoorthy 2014). For present purposes, the question was formulated as follows: "How many of the following scholarly contributions have you completed in the past *three* years?" (Question D4), with separate responses for: "scholarly books you authored or co-authored" (D4/1), "scholarly books you edited or co-edited" (D4/2), "articles published in an academic

book or journal" (D4/3), "research report/monograph written for a funded project" (D4/4), "paper presented at a scholarly conference" (D4/5), and "professional article written for a newspaper or magazine" (D4/6). Exact definitions were not provided, as these were assumed to be self-explanatory.

The next question (D5) was formulated as follows: "What percentage of your publications in the last three years were: peer-reviewed" (D5/6); published in a language different from the language of instruction at your current institution (D5/1); or co-authored with colleagues located in other (foreign) countries?" (D5/3). The questionnaire distinguished explicitly between different types of publication; importantly, Polish academic scientists are used to counting different publication types for institutional reporting purposes.

The survey instrument facilitated comparison of the productivity of internationalists and locals in terms of scholarly books authored and co-authored or edited and co-edited; articles published in a book or journal (and article equivalents); research reports or monographs written for a funded project; professional articles written for a wider audience; internationally co-authored articles (and article equivalents); English language articles (and article equivalents); and papers presented at scholarly conferences. For means, standard deviations, and minimum and maximum values, see Table 10. In general, internationalists were found to be more productive than locals on all productivity items; all differences were statistically significant ($p < 0.001$) with the exception of professional articles written for newspapers or magazines.

On average, internationalists are much more productive in terms of internationally co-authored publications. Assuming that locals' productivity is 100% (see LOC vs. INT in Table 10), internationalists' productivity for IC-PRA is 2,320% and 1,600% for IC-PRAE. For ENG-PRA, internationalists' productivity is 290.9%, and for ENG-PRAE, it is 276.5%. For other publication types, internationalists' productivity is on average 30–70% higher than that of locals: edited book 133.3%, article 134.9%, PRAE 148.2%, PRA 157.6%, book 150%, conference paper 166.7%, report 200%.

Internationalists are also a world apart from locals in terms of international co-authorships. They are almost three times as productive in terms of publications in English, about 70% more productive in terms of conference papers, and about 50% more productive in terms of PRA and PRAE. In short, Hypothesis 5 is supported.

Table 10. Average individual research productivity by publication type (internationalists, locals, and all scientists) for the 3-year reference period and difference between internationalists and locals (LOC = 100%) by publication type.

	Internationalists (INT)				Locals (LOC)				All				LOC vs. INT
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	LOC = 100%
Books authored/co-authored	0.6**	1.2	0	18	0.4	1.2	0	30	0.5	1.2	0	30	150.0
Books edited/co-edited	0.4***	0.9	0	9	0.3	0.8	0	7	0.3	0.8	0	9	133.3
Research reports/monographs written for a funded project	0.8***	1.8	0	25	0.4	1.3	0	30	0.6	1.6	0	30	200.0
Papers at a conference	5.0***	6	0	30	3.0	5	0	30	4	6	0	30	166.7
Articles (newsp. or magazine)	1.1	3	0	30	1.0	3.1	0	30	1.1	3	0	30	100.0
Peer reviewed articles (PRA)	4.79***	6.63	0	33	3.04	5.17	0	30	3.94	6.03	0	33	157.6
Peer reviewed article equivalents (PRAE)	8.3***	11	0	106.2	5.6	9.1	0	165	7	10.2	0	165	148.2
Int. co-authored peer-rev. articles (IC-PRA)	1.16***	3.15	0	33	0.05	0.47	0	13.3	0.62	2.35	0	33	2,320.0
Int. co-authored peer-rev. article equivalents (IC-PRAE)	1.6***	4.3	0	42.8	0.1	0.7	0	20	0.9	3.2	0	42.8	1,600.0
English language peer-reviewed articles (ENG-PRA)	3.2***	5.3	0	33	1.1	2.8	0	30	2.2	4.4	0	33	290.9
English language peer-rev. article equivalents (ENG-PRAE)	4.7***	7.6	0	58.4	1.7	3.9	0	43.2	3.3	6.3	0	58.4	276.5

*p < 0.05; **p < 0.01; ***p < 0.001

Research results: bivariate analysis

Working time distribution: internationalists vs. locals

H6: Working time distribution hypothesis: On average, internationalists work longer hours and spend more time on research, less time on teaching, and more time on administration.

This section reports the results of independent two-sample t-testing. (T-tests assess the difference in values for paired observations. When the variance in the compared populations is equal (based on Levene's test of homogeneity of variance), Student's t-test is used; otherwise, Welch's two sample t-test is used.) In the present case, the dataset captured five dimensions of academic work: teaching, research, service, administration, and other academic activities. The focus here was on differences in mean working hours between internationalists and locals in each academic cluster, based on weekly hours during teaching and non-teaching periods of the academic year.

These hours were annualized, assuming that a figure of 60% for the former and 40% for the latter would be a good approximation for the Polish system.

Differences between the two subpopulations in various categories of working hours (by academic activity) are summarized in Table 11. The results are based on two-sided tests that assume equal differences in arithmetic means (with significance level $\alpha = 0.05$). For each pair with a statistically significantly mean difference from zero, the larger (INT or LOC) is specified. T-tests for equality of two arithmetic means (INT vs. LOC) were performed for each of the five types of academic activity, for each of the seven academic clusters, and for soft clusters combined and hard clusters combined. (All differences were statistically significant).

Table 11. Differential working hours by academic activity and academic cluster based on t-tests for equality of means for INT vs. LOC. Question B1: "Considering all your professional work, how many hours do you spend in a typical week on each of the following activities (when "classes are in session" and when "classes are not in session")?" (Expressed as annualized mean weekly hours.)

	HUM	**SOC**	**PHYS MATH**	**LIFE**	**ENGI TECH**	**AGRI CULT**	**MED HEALTH**	**Soft combined**	**Hard combined**
Teaching				LOC					LOC
Research	INT	INT	INT	INT			INT	INT	INT
Service								INT	
Administration				INT			INT		INT
Other									
Total	INT	INT						INT	INT

The mean differential in annualized total weekly working time for internationalists and locals is 4.4 hours (see Table 12). The picture that emerges here portrays Polish academia as traditional. On average, internationalists spend less time than locals on teaching-related activities and much more time (about +30%) on research, as well as more time on administrative duties. However, there are substantial cross-disciplinary differentials in total weekly working time distribution, ranging from 5.9 hours for humanities to 11.4 hours for social sciences (see Table 17 in Data Appendices).

In other words, as compared to Polish locals in social sciences, Polish internationalists in social sciences spend an average 64 additional full working days in academia per year (i.e., 11.1 hours more per week x 46 weeks, divided by 8 hours per day). More specifically, they spend an average 9.4 additional hours per week (or 54 additional days) on research. Not surprisingly, internationalists in social sciences report the longest weekly working hours and the second longest research hours (after physical sciences and mathematics). For Polish internationalists, longer working hours seem standard (and especially more research hours). The cross-disciplinary difference is stronger in soft disciplines. In summary, Hypothesis 6 is supported.

Table 12. Working hour differentials by type of academic activity (for scientists from all academic clusters combined) based on t-tests for equality of means for INT vs. LOC. Question B1: "Considering all your professional work, how many hours do you spend in a typical week on each of the following activities (when "classes are in session" and when "classes are not in session")?" (Expressed as annualized mean weekly hours).

	Mean hours per week (annualized)						
	INT	LOC	**T-statistics value**	**P-value**	**Significantly larger mean (INT or LOC)**	**% difference (INT vs. LOC)**	**Hours per week difference (INT vs. LOC)**
Teaching	14.8	16.0	-2.875	0.004	LOC	-7.6	-1.2
Research	22.3	17.0	9.201	<0.001	INT	30.8	5.3
Service	5.5	5.4	0.121	0.904	--	0.8	0.0
Administration	6.7	5.6	3.749	<0.001	INT	18.9	1.1
Other	5.3	5.3	0.056	0.955	--	0.3	0.0
Total	49.1	44.7	4.690	<0.001	INT	9.8	4.4

Teaching and research role orientation: internationalists vs. locals

H7: Academic role orientation hypothesis: Internationalists are more research-oriented than locals.

The existing literature suggests that research internationalization is correlated with high research orientation (Rostan, Ceravolo and Metcalfe 2014; Shin and Cummings 2010; Teodorescu 2000). The Polish system as a whole emerges from this research as entirely traditional. The results of the z test for equality of fractions for the two subpopulations are based on two-sided tests with a significance level of $\alpha = 0.05$. Using the Bonferroni correction, the tests were adjusted for all pairwise comparisons within a row for each innermost sub-table. Z tests for the equality of fractions (INT vs. LOC) were performed for each of the four categories of teaching and research orientation. Correspondingly, as before, for each pair with a fraction difference significantly different from zero, the larger category appears in the last column (Table 13).

The stronger research role orientation among internationalists is statistically significant, as is the higher teaching role orientation among locals ($P < 0.001$). In other words, internationalists value research more than their local colleagues. A primary interest in teaching virtually excludes Polish scientists from the class of internationalists; the percentage of internationalists who are primarily interested in teaching is 1.1 percent. However, contrary to the existing evidence in relation to teaching-research competition (Fox 1992; Ramsden 1994; Stephan 2012; Stephan and Levin 1992), 18.6% of those interested "in both, but leaning towards teaching" were internationalists. More than 80% of internationalists were research-oriented as

compared to about 60% of locals. In Poland, research role orientation is a powerful indicator of the internationalist—indeed, it is almost a statistical must—while being teaching-oriented almost precludes membership of this class. On that basis, Hypothesis 7 is supported (although closer examination by academic cluster proved inconclusive).

Table 13. Results of z test for equality of fractions (all clusters of academic disciplines combined). (Question B2: "Regarding your own preferences, do your interests lie primarily in teaching or in research?")

	Internationalists (INT) %	Locals (LOC) %	P-value	Significantly larger fraction
Primarily in teaching	1.1	4.3	<0.001	LOC
In both, but leaning toward teaching	18.6	34.9	<0.001	LOC
In both, but leaning toward research	63.2	50.7	<0.001	INT
Primarily in research	17.1	10.1	<0.001	INT

Research results: multivariate analysis

Logistic regression analysis

H8: Individual predictors hypothesis: Individual predictors of being an internationalist are more important than institutional predictors.

Model approach (I): predictors of collaboration with international research colleagues

What are the predictors of being an internationalist? What makes some Polish scientists more likely than others to collaborate with international colleagues? The dependent variable was faculty internationalization in research ("collaborate with international colleagues in research"; D1/4; *Yes*/*No*). An analytical model for studying internationalization in research was developed on the basis of the existing literature, notably Cummings and Finkelstein (2012), Rostan, Ceravolo, and Metcalfe (2014), Finkelstein and Sethi (2014), Finkelstein, Walker, and Chen (2013), and Abramo, D'Angelo, and Solazzi (2011). From forty two selected personal and institutional characteristics, the independent variables were grouped into individual variables (36) and institutional variables (6). Individual variables were further divided into six clusters (Table 14): personal/demographics (15 variables), internationalization and collaboration (11 variables), socialization to academia (2 variables), academic behaviors (4 variables), research productivity (1 variable), and academic attitudes and role orientation (3 variables).

Table 14. Internationalization in research: variables in the model (survey question numbers in parentheses).

Individual variables
Personal/Demographics
Gender (F1)
Marital status (married or not) (F3)
Spouse employed (F4)
Spouse an academic (F5)
Spouse education level (F8-3)
Children under 18 at home (F6)
Age (F2)
Academic experience – years since first employment (A4)
PhD or lower degree (A1)
Habilitation degree (A1)
Full professorship (A1)
My academic discipline/field is important (B4)
My institution is important (B4)
Satisfaction with current job (B6)
Cluster of academic discipline (hard vs. soft) (A2)
Internationalization and collaboration
Emphasize international perspective or content in their courses (C4/5, 1 and 2)
Most international students are currently international (C4/10, 1 and 2)
Teaching any courses abroad (C5/2, Yes/No)
Teaching any courses in a foreign language (C5/2, Yes/No)
Research primarily international in scope or orientation (D2/5, 1 and 2)
Employ primarily mother tongue in research (F12/1, Yes/No)
Publishing in a foreign country (D5/4, Yes/No, >0)
Publishing in a foreign language (D5/1, Yes/No, >0)
Publishing works co-authored with colleagues located in other countries (D5/1, Yes/No, >0)
Spent at least two years in other countries since the award of their first degree (F13/3, Yes/No)
PhD earned in a foreign country (A1/2/2).
Socialization to academia
Intensive faculty guidance (A3)
Research projects with faculty (A3)
Academic behaviors
Annualized mean weekly research hours (60% in session, 40% not in session) (B1)
Annualized mean weekly teaching hours (60% in session, 40% not in session) (B1)
Annualized mean weekly admin. hours (60% in session, 40% not in session) (B1)
Annualized mean weekly total hours (60% in session, 40% not in session) (B1)
Academic attitudes and role orientation
Research-oriented (only answer 4) (B2)
Scholarship is original research (B5)
Basic/theoretical research (D2)
Research productivity
Peer-reviewed articles (PRA) (D4/2 and D4/3)
Institutional variables
Institutional environment

Strong performance orientation (E4)
Institutional type (A9)
Research considered in personnel decisions (E6)
Availability of research funds (B3)
Supportive attitude of administration (E4)
Who has primary influence in establishing international linkages (individual/faculty) (E1)

All categorical variables were dichotomized using a re-coding procedure. Pearson Rho correlation tests were then conducted to identify significantly correlated predictors of the dependent variable. These predictors were entered in a logistic regression model. When multicollinearity was tested using an inverse correlation matrix, no independent variables were found to be strongly correlated with others. Additionally, principal component analysis (PCA) was performed to determine whether any variables could be assigned to homogenous groups by virtue of a high level of correlation. No significant interdependence was found between any of the variables. The model was estimated using a stepwise backward elimination based on the Wald criteria, so only significant variables were included in the model. Iterations stopped at the 32nd step. The predictive power of the model (as measured by Nagelkerke's R^2) was 0.502. The results for the model are presented in Table 15.

Table 15. Selected model statistics of logistic regression for being internationalist in research: predictors of collaboration with international colleagues.
Nagelkerke's R^2 = 0.502

	B	Standard Error	Wald	P-value	Exp(B)	DIAG
Gender						1.18
Spouse employed						1.253
Spouse an academic						1.114
Spouse education level						1.106
Children under 18 at home						1.119
Age						2.16
Habilitation degree						1.533
Full professorship	2.182	0.672	10.528	0.001***	8.862	2.039
My academic discipline/field is important						1.083
My institution is important						1.19
Satisfaction with current job						1.187
Intensive faculty guidance?						1.104
Research projects with faculty?						1.143
Annualized mean weekly research hours	0.060	0.022	7.176	0.007**	1.062	2.601
Annualized mean weekly teaching hours						1.448
Annualized mean weekly admin. hours						1.492
Annualized mean weekly total hours						2.987
Research-oriented						1.129
Scholarship is original research						1.082
Basic/theoretical research						1.148
Strong performance orientation						1.071
Institutional type						1.237

Research considered in personnel decisions						1.152
Availability of research funds						1.088
Supportive attitude of administration						1.09
Who has primary influence in establishing international linkages (individual/ faculty)	1.230	0.491	6.286	0.012*	3.421	1.083
Emphasize international perspective or content in their courses						1.143
Teaching any courses abroad						1.231
Teaching any courses in a foreign language	1.048	0.464	5.111	0.024*	2.853	1.305
Research primarily international in scope or orientation	1.546	0.441	12.270	0.000***	4.692	1.31
Employ primarily mother tongue in research						1.32
Publishing in a foreign country						2.595
Publishing in a foreign language						2.387
Publishing works co-authored with colleagues located in other countries	1.303	0.586	4.948	0.026*	3.680	1.589
Spent at least two years in other countries since the award of their first degree						1.314
PhD earned in a foreign country						1.086
Hard scientist	1.110	0.480	5.348	0.021*	3.034	1.488
Peer-reviewed articles (PRA)						3.14
Constant	-3.246	0.740	19.246	0.000***	0.039	

***p<0.001; **p < 0.01; *p < 0.05

Six individual variables and one institutional variable proved to be statistically significant: holding full professorship and hard scientist (in the cluster of personal/demographic variables); annualized mean weekly research hours (academic behaviors); teaching any courses in a foreign language; research primarily international in scope or orientation; publishing works co-authored with colleagues located in other countries (internationalization and collaboration); and individual faculty responsible for establishing international linkages (institutional variables). All other variables were statistically insignificant at the confidence level of 0.05. Holding full professorship emerged as a powerful determinative predictor of being an internationalist (Exp(B) = 8.862), substantially increasing the odds of being an internationalist (other predictors being held constant). Defining one's research as primarily international in scope or orientation was also an important predictor of being an internationalist (based on the definition used here) (Exp(B) = 4.692), as was individual's primary influence in establishing international linkages (Exp(B) = 3.421) and being a hard scientist (Exp(B) = 3.034). Longer weekly research hours were predictors of being an internationalist: a one-unit increase (i.e., 1 hour) increases the odds by about 6.2 % on average (*ceteris paribus*) The odds were also increased significantly increased by teaching in a foreign language (Exp(B) = 2.853) and international publication co-authoring (Exp(B) = 3.034).

Importantly, in the context of previous literature on international research collaboration, statistically insignificant variables in the personal/demographics cluster included gender, spouse and family, age, as well as attachment to one's discipline and institution. In previous research in other countries, being female was generally found to be correlated with lower international collaboration (Fox et al. 2016; Abramo,

D'Angelo, and Murgia 2013), as was having children at home (Kyvik and Teigen 1996; Ackers 2008). In Poland, only reaching the academic career pinnacle (full professorship) increases the odds of collaborating internationally in research; neither doctoral degree nor habilitation degree enter the equation. In other words, international research collaboration is strongly correlated with high research achievement (leading to the full professorship title, as research is the only criterion used in the Polish system; the full professorship title as a binary variable is correlated with research productivity understood as the number of peer-reviewed articles published in the reference period). Age is not a statistically significant predictor; full professors rather than merely older scientists tend to be more often engaged in international collaboration (for a quantitative and qualitative generational approach, see Kwiek 2017). In summary, Hypothesis 8 is supported.

Model approach (II): How internationalization influences productivity

H9: Productivity type hypothesis: Dimensions of internationalization differ in their impact on different productivity measures.

A modeling approach was also used to investigate how general variables and variables related to internationalization (in teaching and research) influence various aspects of productivity. As measures of productivity, dependent variables included PRA, PRAE, IC-PRAE, and ENG-PRAE. Productivity-related independent variables included gender, age, institutional type (reference: academy), academic degree (reference: PhD), academic field (reference: HUM). Finally, internationalization-related independent variables included responses to the following statements: "emphasize international perspective or content in their courses" (C4/5, 1 and 2); "collaborate with international colleagues in research" (D1/4, *Yes/No*); "most students are currently international" (C4/10, 1 and 2);, "teaching any courses abroad" (C5/2, *Yes/No*); "teaching any courses in a foreign language" (C5/2, *Yes/No*); "research primarily international in scope or orientation" (D2/5, 1 and 2); "employ in research primarily mother tongue" (F12/1, *Yes/No*); "publishing in a foreign country" (D5/4, *Yes/No*, >0); "publishing in a foreign language" (D5/1, *Yes/No*, >0); "publishing works co-authored with colleagues located in other countries" (D5/1, *Yes/No*, >0); "spent at least two years in other countries since the award of their first degree" (F13/3, *Yes/No*); and "PhD earned in a foreign country" (A1/2/2).

Table 16 details the results of regression analysis, with models for each of the four productivity types (PRA, IC-PRA, ENG-PRA and PRAE) (all types: peer-reviewed). For each productivity type, there are three separate models: all scientists (ALL), internationalists (INT), and locals (LOC). In total, then, twelve models were estimated; beta coefficients and significance of parameters are shown for each.

In the first regression model of productivity (dependent variable: PRA) for all scientists (Model 1), the general independent variables significantly associated with productivity were age, habilitation degree, full professorship title, and life sciences; the

significant internationalization-related independent variables were publishing in a foreign country, publishing in a foreign language, and international co-authorship. The model explains 41% of the variance ($R^2 = 0.409$). In summary, older scientists are likely to produce fewer papers, and all internationalization-related variables increase productivity.

In the second regression model of productivity (PRA) for internationalists (Model 2), the general independent variables significantly associated with productivity were age, habilitation degree, full professorship title; and two internationalization-related independent variables: publishing in a foreign language, and international co-authorship. As in Model 1, there was a powerful negative correlation between age and productivity. The model explains almost 40% of the variance ($R^2 = 0.388$). Finally, in the regression model of productivity (PRA) for locals (Model 3), only two independent variables (both internationalization-related) were significant: publishing in a foreign country and publishing in a foreign language ($R^2 = 0.315$).

In models 4 through 6, IC-PRA was the dependent variable; in Models 7 through 9, the dependent variable was ENG-PRA; and in Models 10 through 12, PRAE was the dependent variable—again with separate models for all scientists, internationalists, and locals.

The analyses reveal some interesting generalizations and several exceptions. Interestingly, gender does not enter the equation in any model for any productivity-related dependent variable. Age as an independent variable is not correlated with productivity for locals in any of the four clusters of regression models, nor for the three types of scientist in the case of article equivalents as dependent variable (Models 10–12). This can be explained by the fact that locals are more attached to traditional (and generally less competitive) publishing outlets for books and edited books. Habilitation degree and professorship are significantly correlated with all scientists and internationalists (rather than with locals), perhaps explaining why international collaboration is strongly correlated with productivity as measured through all its dependent variables (PRA, IC-PRA, ENG-PRA, and PRAE). For locals, the correlation holds only for article equivalents, which means that locals move up the ladder of scientific degrees and titles through traditional outlets (books and edited books) rather than articles. International content or orientation in teaching and teaching international students as (teaching-related) internationalization independent variables are not correlated with productivity. Teaching in a foreign language is negatively correlated with productivity in ENG-PRA and PRAE models. This confirms the traditional teaching/research trade off, or competition rather than mutuality (Fox 1992) in Polish academia, or at least supplies the missing link between internationally-oriented teaching and research productivity, in line with previous findings (Kwiek 2015c). Interestingly, among internationalization-related independent variables, neither long-term stay abroad nor foreign PhD are correlated with productivity, confirming previous findings about mobility, collaboration, and productivity (Ackers 2008). Only in the case of the IC-PRA model for locals, productivity increases with long-term stay abroad (on average by 0.7 internationally co-authored peer-reviewed

article in the reference period of three years) and decreases with foreign PhD (on average by 1.5). Hypothesis 9 is therefore supported.

Summary, discussion, and conclusions

Within the academic profession, international research collaboration plays an increasingly stratifying role. Those who do not collaborate internationally may be losing more than ever before as patterns of funding and prestige change rapidly, favoring research internationalists and leaving locals behind. This vertical stratification of institutions (reflected in national and international ranking systems) and of scientists (reflected in changing requirements for career progression) is reshaping national science systems in Central and Eastern Europe (Antonowicz et al. 2017; Antonowicz 2016; Dakowska 2015). As higher education massification occurs, stratification follows, at both institutional and individual levels.

At the level of the individual scientist, this increasing inequality is primarily driven by increasing stratification of academic performance, which is closely linked to international research stratification. Other forms of stratification disrupting the traditional academic community relate to academic salary, academic power, academic role, age, as well as stratification in terms of academic publishing, gender, and research funding (see Kwiek 2019). The scientific community is heavily divided by research achievement, income, academic position, gender, age cohort, distribution of teaching and research time, research funding opportunities, and space in prestigious journals. Overall, this stratification of the global scientific community is clearly research-based, and internationalization is at its center.

As a clearly defined subgroup of Polish scientists (51.4%), internationalists emerge from this research as a different academic species. The findings confirm that internationalists differ significantly from locals or internationally non-collaborating colleagues. Internationalists are predominantly male, and the gender differential has powerful policy implications. If an individual's success in the global stratified academia is based on research rather than on teaching, service, or administration, and if success in research and research productivity is driven by international collaboration, then female scientists are likely to be losing out more than ever before in terms of funding and prestige. This is especially the case in resource-poor systems in which competition is tougher and "accumulative disadvantage" (Cole and Cole 1973: 146) increasingly makes the poor disproportionately poorer. International research stratification, in which international collaboration leads to higher publishing rates and higher citation rates, emerges here as more harmful to female academics. In the Polish context, 55% of female academics are locals (as compared to 44% of their male colleagues). Consequently, the female journey up the academic ladder is likely to be longer and more difficult, with lower access to increasingly competitive individual research funding.

Table 16. Regression of research productivity by productivity type and class of scientists (beta coefficients and significance). Only scientists employed full-time in the university sector and involved in both teaching and research were included.

Independent variables	Productivity – PRA			Productivity – IC-PRA			Productivity – ENG-PRA			Productivity – PRAE		
	1	2	3	4	5	6	7	8	9	10	11	12
	All scientists (ALL)	Internationalists (INT)	Locals (LOC)	All scientists (ALL)	Internationalists (INT)	Locals (LOC)	All scientists (ALL)	Internationalists (INT)	Locals (LOC)	All scientists (ALL)	Internationalists (INT)	Locals (LOC)
General variables												
Gender	-0.083*	-0.085*		-0.04*	-0.054*		-0.076**	-0.079*				
Age									-0.668*			
Institutional type: university and university-type institution							0.798*					
Institutional type: technical university and polytechnic (reference: academy)												
Academic degree: MA	2.419**	3.026**		0.849*	1.039*	0.316*	2.229***	2.670***		2.809**	3.233*	2.540*
Academic degree: Habilitation	4.756***	5.638***		2.011***	2.466***		3.995***	4.471***		6.786***	7.468***	5.003*
Academic degree: Full professorship (reference: PhD)												
Academic field: SOC				2.172***	2.498***		2.287**	2.796**		-7.250***	-7.463***	-8.690*
Academic field: PHYSMATH	1.219*			1.358***	1.719***		2.310***	2.501***	1.703**	-3.304*	-4.290*	
Academic field: LIFE										-5.205***	-5.566***	-4.001**
Academic field: ENGITECH									2.254*	-5.781**	-7.463**	
Academic field: AGRICULT										-3.312*	-4.017*	
Academic field: MEDHEALTH (reference: HUM)												
Internationalization-related variables												
Emphasize international perspective or content in their courses												
Most students are currently international												
Teaching any courses abroad												-10.112**
Teaching any courses in a foreign				0.593*	0.799*				-0.794*			-2.771*

language												
Research primarily international in scope or orientation						0.312*						
Employ primarily mother tongue in research							0.845*		1.001*			
Publishing in a foreign country	2.828**		3.642***						1.719**	3.722*		7.185***
Publishing in a foreign language	3.815**	6.166***	2.536*				3.645***	4.401***	1.410**	6.905***	10.294***	4.862**
Publishing works co-authored with colleagues in other countries	2.862**	3.519***		3.585***	3.688***	2.922***	3.742***	3.596***	3.292***	4.855***	5.368***	
Spent at least two years in other countries since first degree						0.688*						
PhD earned in a foreign country						-1.452**						
(Constant)	2.304	2.081	0.281	0.817	0.937	-0.182	0.853	0.951	-0.321	2.077	2.062	11.382
R^2	0.409	0.388	0.315	0.314	0.324	0.422	0.451	0.421	0.472	0.407	0.382	0.455

*p < 0.05; **p < 0.01; ***p < 0.001.

Internationalists are older; they have longer academic experience and higher academic degrees, and they occupy higher academic positions. In resource-poor systems like Poland, internationalists are in a majority only after the age of 50, among those with more than 20 years of academic experience and a habilitation degree and associate professorship at minimum. The emerging pattern is clear (and statistically significant); research internationalization reaches the high levels achieved in resource-rich systems only for the tiny class of full professors (74.6% of whom are internationalists). There is also powerful cross-disciplinary differentiation; the share of internationalists reaches 80% in the physical sciences and mathematics cluster as against only 36.3% in the social sciences, and for only half of the full professors in social sciences as against more than 90% in the physical sciences and mathematics. In line with previous research (Kyvik and Larsen 1997; Piro, Aksnes, and Rørstad 2013), the present findings confirm that internationalization is highly field-sensitive. The share of young internationalists is certainly increasing due to new research programs funded by the National Research Council (or NCN, founded in 2011), highly competitive and dedicated specifically for young academics (Bieliński and Tomczyńska 2018).

International collaboration does not occur at the expense of domestic collaboration; in fact, internationalists collaborate domestically on a mass scale, although this dimension of research collaboration has rarely been studied (Sooryamoorthy 2014; Jeong, Choi, and Kim 2011). Only 20.5% of internationalists do not collaborate domestically, for unknown reasons that may range from lack of time to lack of funding to limited opportunities for co-publishing internationally. At the other extreme, only half of locals collaborate domestically—that is, half of those who do not collaborate internationally also fail to collaborate domestically, with powerful field differentiation. In the humanities and social sciences, 63.3% of locals do not collaborate domestically; this means that in the cluster of soft academic disciplines, the “lonely scholar” model prevails.

In terms of research productivity, internationalists co-author internationally six times more often than locals, among whom international co-authorship of publications is marginal at 2.1% (as compared to 13.8% for internationalists). Across all academic clusters, internationalists consistently produce more than 90% of internationally co-authored publications, and in PHYSMATH, SOC and LIFE clusters, the figure is 97–99.9%. In these clusters, no international collaboration means no internationally co-authored publications.

Scientists in the hard fields who do not collaborate internationally report that just 3.2% of their publications are internationally co-authored; in the soft fields, the figure is just 1.9%. The policy implication is that large-scale international co-authorship is generally only produced by internationalists on the basis of international research collaboration. Only a negligible fraction of publications from nationally isolated science (produced by Polish locals) can be internationally co-authored, and internationally co-authored publications depend entirely on collaborative activities with international colleagues. Given the current policy goal of increasing Polish visibility in global science,

supporting research locals may be counter-productive, as this would deprive internationalists of already limited research funds.

The survey instrument facilitated comparison of the productivity of internationalists and locals in relation to a wide array of publication types: scholarly books authored and co-authored, edited and co-edited, articles (and article equivalents), research reports written for a funded project, professional articles written for wider audiences, internationally co-authored articles (and article equivalents), English language articles (and article equivalents), and papers presented at scholarly conferences. For all such items, internationalists were found to be more productive than locals to a statistically significant extent ($p < 0.001$).

Internationalists emerge from this study as much more productive in terms of internationally co-authored publications: 2,320% of the productivity of locals for peer-reviewed articles and 1,600% for peer-reviewed article equivalents. For English language peer-reviewed articles, the figure is 290.9%, and for article equivalents, it is 276.5%. In this sense, internationalists are a world apart from locals in terms of international co-authorships and almost three times as productive in terms of publications in English. They are also about 70% more productive in terms of conference papers and about 50% more productive in terms of peer-reviewed articles, article equivalents, and books, and they tend to produce twice as many reports for funded projects.

In terms of working time distribution and academic role orientation, Polish academia is fairly traditional; internationalists tend to spend less time than locals on teaching-related activities, more time on research, and more time on administrative duties, with cross-disciplinary differentials in total weekly working time distribution ranging from 5.9 hours for humanities to 11.4 hours for social sciences. Internationalists exhibit higher research role orientation while locals are more teaching-oriented. Being interested primarily in teaching virtually excludes Polish scientists from the class of internationalists, of whom only 1.1% are primarily interested in teaching.

Finally, the multivariate analyses identified some new predictors of international research collaboration. Six individual variables and one institutional variable emerged as statistically significant, substantially increasing the odds of being internationalist in research: full professorship, hard academic disciplines, annualized mean weekly research hours, research international in scope or orientation, teaching in a foreign language, international co-authorship, and individual rather than institutional forging of international linkages. In relation to the impact of teaching- and research-related internationalization on productivity (as measured by different proxies), gender did not feature in any model with a productivity-related dependent variable. Age as an independent variable was not correlated with productivity for locals and it was negatively correlated for all scientists and internationalists. Habilitation degree and professorship were positively correlated with higher productivity for all scientists and internationalists but not for locals. Unsurprisingly in the Polish context, teaching- and internationalization-related independent variables (such as international content in

teaching, teaching international students or teaching in a foreign language) were negatively correlated with productivity. The traditional teaching/research trade-off in Polish academia was also statistically confirmed. Among internationalization-related independent variables, generally neither long-term stays abroad, nor PhD earned abroad were positively correlated with productivity, confirming previous findings about mobility, collaboration, and productivity (Ackers 2008).

The policy implications of this research are straightforward. If the global network of science emerges because scientists "connect with each other on a peer-to-peer basis, and a process of preferential attachment selects specific individuals into an increasingly elite circle" (Wagner 2018: x), then locals in every country (with the possible exception of the USA) are gradually being excluded from the ongoing global transformation. As a relative newcomer and heavily under-resourced participant in global science, Poland must consider making radical changes to the structure of its scientific workforce. Among these, research locals should increasingly be replaced by internationalists, whether new younger scientists or older scientists as locals-turned-internationalists with new international collaborative opportunities. The current 50:50 division, in which only half of academic scientists collaborate internationally in research, is not sustainable in the long term. The post-communist transition period of three decades (1989–2019) is over, and no further excuses should be accepted for the failure to reform the academic science sector or to adequately fund it. Increasingly, top scientists globally opt for collaborative, networked science that is locally rooted through training and institutions and nationally funded. Poland must follow suit by transforming its academic faculty and providing large-scale funding for international research collaboration to avoid creeping isolation at global level.

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Data Appendices

Table 17. Working hours differentials by type of academic activity and cluster of academic disciplines. Results of t-tests for the equality of means for internationalists (INT) vs. locals (LOC). Question B1: "Considering all your professional work, how many hours do you spend in a typical week on each of the following activities? (when 'classes are in session' and when 'classes are not in session')?" (annualized mean weekly hours).

Cluster of academic disciplines	Academic activity	Mean hours per week (annualized)		T-statistics value	P-value	Group with a sig. larger mean (INT or LOC)	% Difference (INT vs. LOC)	Hours difference per week (INT vs. LOC)
		INT	LOC					
HUM	Teaching	16.1	15.2	1.063	0.289	--	6.1	0.9
	Research	23.4	18.6	3.978	<0.001	INT	25.4	4.7
	Service	5.5	4.4	1.713	0.088	--	26.1	1.1
	Administration	5.5	5.7	-0.277	0.782	--	-2.9	-0.2
	Other	4.9	4.9	0.012	0.991	--	0.1	0.0
	Total hours	49.6	43.7	2.963	0.003	INT	13.4	5.9
SOC	Teaching	16.8	17.4	-0.399	0.691	--	-3.2	-0.6
	Research	22.4	13.0	5.625	<0.001	INT	72.5	9.4
	Service	8.3	5.6	1.787	0.077	--	48.0	2.7
	Administration	7.1	5.6	1.657	0.100	--	27.5	1.5
	Other	5.1	5.3	-0.100	0.920	--	-2.2	-0.1
	Total hours	53.3	41.9	3.180	0.002	INT	27.2	11.4
PHYSMATH	Teaching	12.5	14.2	-1.163	0.247	--	-12.3	-1.7
	Research	25.6	17.0	2.922	0.004	INT	50.3	8.6
	Service	4.1	4.9	-0.556	0.580	--	-15.4	-0.8
	Administration	6.4	5.7	0.473	0.638	--	12.0	0.7
	Other	4.5	4.1	0.505	0.615	--	11.4	0.5
	Total hours	47.8	41.8	1.672	0.097	--	14.5	6.1
LIFE	Teaching	14.2	16.8	-2.557	0.011	LOC	-15.4	-2.6
	Research	24.0	19.7	3.202	0.002	INT	21.9	4.3
	Service	4.4	4.0	0.667	0.505	--	9.6	0.4
	Administration	7.7	6.0	2.247	0.026	INT	29.0	1.7
	Other	5.4	4.5	1.103	0.272	--	19.9	0.9
	Total hours	49.3	46.3	1.446	0.149	--	6.5	3.0
ENGINTECH	Teaching	13.8	15.2	-1.897	0.059	--	-9.5	-1.4
	Research	19.0	17.3	1.475	0.141	--	9.7	1.7
	Service	5.7	5.4	0.464	0.643	--	5.0	0.3
	Administration	6.3	5.3	1.968	0.050	--	17.8	1.0
	Other	5.8	5.8	-0.005	0.996	--	-0.1	0.0
	Total hours	47.4	44.9	1.429	0.154	--	5.6	2.5
AGRICULT	Teaching	15.7	19.4	-1.707	0.091	--	-19.2	-3.7
	Research	21.0	17.8	1.665	0.099	--	17.8	3.2
	Service	4.6	5.0	-0.369	0.713	--	-8.0	-0.4
	Administration	6.3	5.9	0.423	0.674	--	7.8	0.5
	Other	5.8	6.3	-0.349	0.728	--	-7.9	-0.5
	Total hours	49.8	51.3	-0.412	0.682	--	-3.1	-1.6
MEDHEALTH	Teaching	16.0	14.7	0.973	0.332	--	8.9	1.3
	Research	19.9	14.3	3.157	0.002	INT	39.3	5.6
	Service	7.2	8.8	-1.046	0.297	--	-18.6	-1.6
	Administration	7.7	5.3	2.914	0.004	INT	45.7	2.4
	Other	5.7	5.5	0.182	0.856	--	3.2	0.2

Cluster of academic disciplines	Academic activity	Mean hours per week (annualized)		T-statistics value	P-value	Group with a sig. larger mean (INT or LOC)	% Difference (INT vs. LOC)	Hours difference per week (INT vs. LOC)
		INT	LOC					
	Total hours	49.0	43.8	1.726	0.086	--	11.9	5.2
SOFT combined	Teaching	16.3	15.9	0.491	0.624	--	2.3	0.4
	Research	23.1	16.7	6.557	<0.001	INT	38.8	6.5
	Service	6.3	4.8	2.206	0.028	INT	30.1	1.4
	Administration	6.0	5.6	0.613	0.540	--	5.5	0.3
	Other	5.0	5.0	-0.101	0.920	--	-1.1	-0.1
	Total hours	50.6	43.1	4.275	<0.001	INT	17.4	7.5
HARD combined	Teaching	14.2	16.0	-3.619	<0.001	LOC	-11.7	-1.9
	Research	22.0	17.3	6.610	<0.001	INT	27.0	4.7
	Service	5.2	5.8	-1.499	0.134	--	-10.8	-0.6
	Administration	6.9	5.6	3.993	<0.001	INT	24.6	1.4
	Other	5.4	5.4	-0.008	0.994	--	-0.1	0.0
	Total hours	48.5	45.8	2.481	0.013	INT	5.9	2.7