

# CHAPTER 7

## Global Research Collaboration: a Vital Resource in a Turbulent World

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### CONTEXT

**T**wo powerful and contradictory forces are shaping the current geopolitical landscape. On the one hand, a movement to retreat from international engagement appears to be gaining momentum in some corners of the globe.

The Brexit campaign in the United Kingdom is a clear example. More than 17 million people, 52% of the population, voted to sever Britain's ties with the European Union, a region representing half a billion people and, at just over a fifth of global GDP, the world's third-largest economy. These ties had existed officially since 1993 and unofficially for the better part of half a century. Whatever one's views on Brexit, the vote has been read by many as expressing scepticism about international engagement, and an apparent enthusiasm for building barriers between countries rather than bridges. The resulting political, economic and social uncertainty in the UK has been well documented. But, despite this, political parties in France, Germany, the Netherlands, Italy, Austria, Sweden, Denmark and others have sounded similar themes.

Meanwhile, in the United States, President Donald Trump campaigned successfully on a vision of America's future that many regard as nativist, America-first, anti-immigration and isolationist. Nearly 63 million Americans voted for candidate Trump. Examples of nationalist policy were easy to find in the first months of his presidency: executive orders restricting

immigration from certain predominantly Muslim countries, a budget proposal calling for increases in military spending and decreases in international aid, a call for proposals to build a “big, beautiful wall” along the US-Mexican border, a directive to review the H-1B foreign worker visa program, and so on.

One final example comes from the southern hemisphere. In March 2017, Australia’s government replaced their 457 visa program for skilled temporary foreign workers with an “Australians first” policy. The new policy will reduce the term of temporary work visas from four to two years, introduce language and labour market testing, and eliminate or substantially reduce the opportunity for visa holders to pursue permanent residency and citizenship. More than 200 jobs will be removed from the list of occupations permitted to be filled by visa-holders, including historian, geophysicist, microbiologist and biochemist (Government of Australia, 2017). While commentators had argued that the 457 visa program needed revision and tightening, this initiative has been seen by many as an expression of troubling nationalist, anti-immigration sentiment (sarahinthesen8, 2017).

On the basis of these three significant cases, it certainly appears that major global forces are moving us away from mutual trust, cooperation and engagement on the international stage. Much has already been written about the economic, social and political causes of this retreat, and I will not add to that literature here. Instead, I wish to call attention to a growing and increasingly important counter-movement.

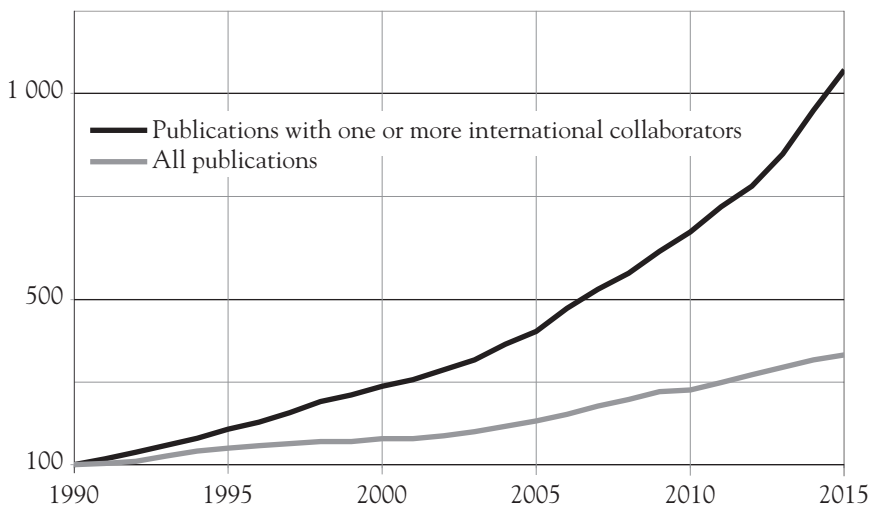
At precisely the time when these anti-international forces seem to be gathering steam, the international community is increasingly facing challenges that are global in nature, and whose solutions inevitably require international cooperation. Examples come easily to mind: health epidemics, international migration and refugee flows, cyber security, poverty and global inequality, threats to water and food security, and more. These challenges do not respect political borders, and may even be exacerbated by them. The existential threat posed by climate change is another striking case in point.

It is not just *implementing* solutions that requires cooperation; increasingly, *finding* solutions also requires cooperation. The best, and perhaps the only, answers to the most complex and pressing global challenges of our time will emerge from sharing data, ideas, perspectives, findings — and failures — between different research communities around the world. Indeed, particularly in these turbulent times, I would argue that international collaboration in research is a vital resource for universities and for prosperity, both domestic and global. Moreover, this phenomenon has the potential to counteract the mounting geopolitical backlash against international engagement noted above. What is my evidence? And, if I am right, what are the possible implications for policy-makers?

## INTERNATIONAL COLLABORATION IS GROWING, GEOGRAPHICALLY CLUSTERED, AND VALUABLE

Let's begin with an intriguing observation. As Figure 1 shows, the growth in international co-publication activity since 1990 has far outstripped overall publication growth over the same period. Figure 1 compares the rate of growth in all research publications with the rate of growth in research publications involving one or more international co-authors. While the number of research publications has more than doubled since 1990, the number of research publications with one or more international co-authors has increased *more than tenfold*. International collaboration is clearly flourishing.

**Figure 1** – Growing International Research Collaboration



Number of scholarly publications globally, 1990 to 2015, indexed to 1990 (1990 = 100).

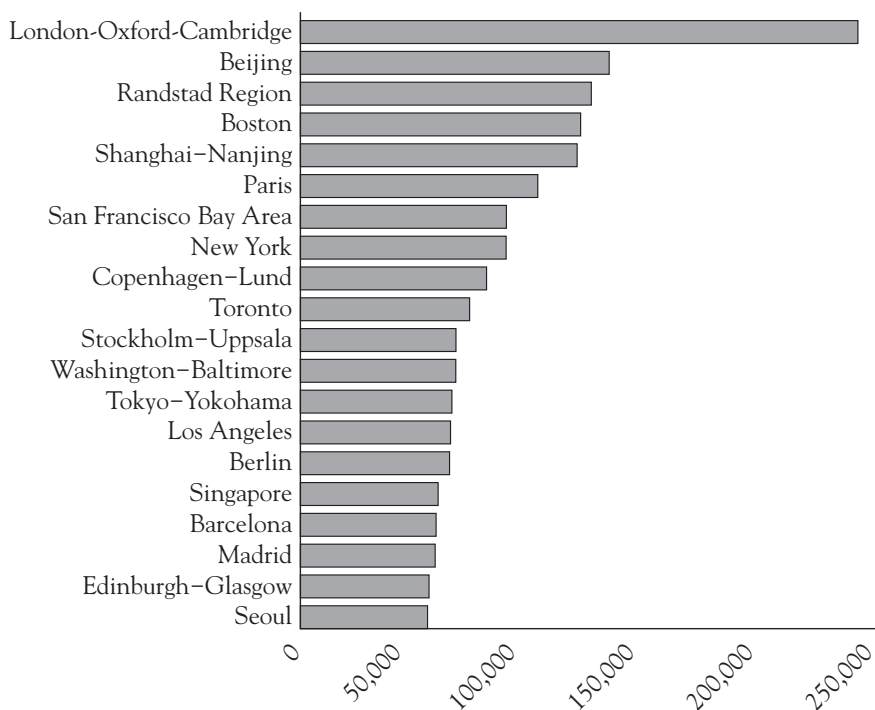
Source: Web of Science® Thomson Reuters, Clarivate Analytics; University of Toronto.

Indeed, since 2010, scholars at the top 50 research-intensive universities in the world (measured by publication volume) have collaborated over a million times (an average of more than 400 collaborations a day) with international partners on peer-reviewed publications, creating a vast, shared knowledge network that crisscrosses the globe.

Figure 2 ranks urban regions by the number of times authors from universities and other research institutions in each respective region have collaborated with authors in other countries on co-authored, peer-reviewed publications. It is worth commenting on two points. First, the smaller than expected number,

and relatively low rankings, of US urban regions shown in Figure 2 reflects the disproportionately large number of opportunities for US authors to engage in collaboration with scholars at other leading research institutions in the same country. While scholars at many US institutions are active international collaborators, the intensity of this activity may be offset to some extent by the scale of their opportunities for domestic collaboration. And second, European programs designed to encourage intra-European exchange and collaboration — including, for example, the European Commission’s Marie Skłodowska-Curie actions, and the EU’s Erasmus exchange program — may help explain the prominence of European countries in Figure 2. Collaborations among EU countries and collaborations among EU and non-EU countries are both growing; comparing the intra- and extra-EU collaboration rates would be an interesting question for future study.

**Figure 2 – Global Collaborations**

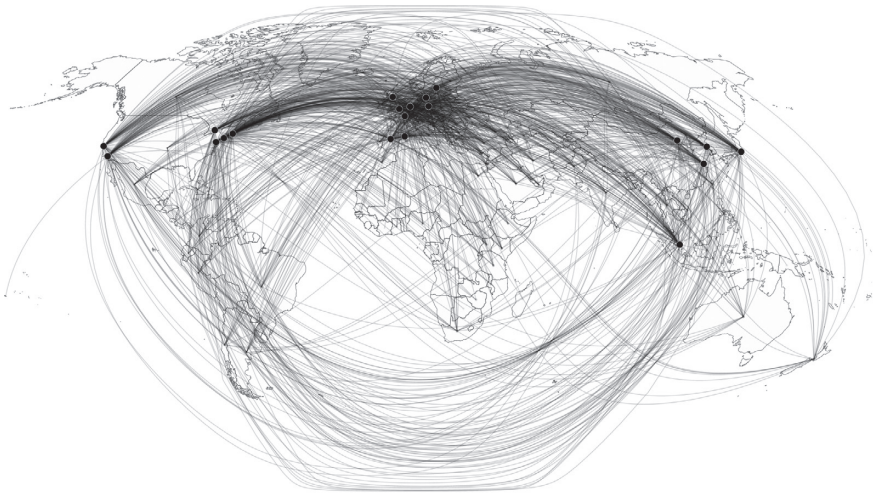


Top 20 urban regions by total number of international co-authored publications, 2011-2016.

Source: Web of Science® Thomson Reuters, Clarivate Analytics; University of Toronto.

Figure 3 offers a geographical representation of the apex of this network. It shows the reach of international collaboration originating from the top 20 urban regions identified in Figure 2 between 2010 and 2015. Each line represents a partnership that produced 100 or more co-publications over the period. Here you can clearly see the role that major urban regions play in shaping — and dominating — global knowledge networks. We can think of these connections as the globe’s arteries — creating and circulating ideas, opening up opportunities and fueling creativity and innovation.

**Figure 3 – International Collaborations**



Top 20 most active urban regions, 100 or more publications, 2010-2015.

This striking evidence raises an obvious question: what forces are driving this remarkable growth in international co-publication? One clue may be found in the recent literature on creativity, collaboration and innovation, which suggests that research conducted by teams that are more internally diverse is more likely to succeed in generating significant innovations (Nooteboom *et al.*, 2007; Spencer, 2011). Diversity can be measured in terms of a variety of dimensions, including occupation, discipline, nationality, culture and other social markers.

Studies in fields from economic geography (Nathan & Lee, 2013), management (Hunt *et al.*, 2015), psychology (Phillips *et al.*, 2008), and complex systems (Hong & Page, 2004), among others, have found that teams, firms, or regions collaborating under conditions of “resource heterogeneity” often perform better on creative, problem-solving, or innovative tasks than those collaborating under conditions of “resource homogeneity”. Nooteboom *et al.*,

(2007, p. 1017) describes the phenomenon in the following way: “When people with different knowledge and perspectives interact, they stimulate and help each other to stretch their knowledge for the purpose of bridging and connecting diverse knowledge.”

Hence, scholars may be more likely to seek international collaborators because they find such research collaborations especially productive. They may also believe the resulting publication will be more successful or innovative, or have a greater impact. These and other factors may help explain the increasing propensity to co-publish internationally.

Indeed, there is some hard evidence to support this conjecture. For example, at the University of Toronto, international collaboration accounted for just under half (46%) of all research publications between 2010 and 2015. But, in the same time span, internationally co-authored papers accounted for fully 82% of the University of Toronto’s Highly Cited Publications (Clarivate Analytics TR, 2017). This pattern is repeated in every one of the top 20 collaborating regions highlighted in Figure 2, with international co-authors disproportionately represented among a region’s most highly cited research. And this pattern is consistent with the findings established by others confirming that, all else equal, research publications featuring international collaborators do indeed tend to be more highly cited than those publications with exclusively domestic authors (Sin, 2011; Khor & Yu, 2016).

If one accepts citation frequency as a reasonable indicator of impact or influence, then it appears that international collaborations are in fact more likely to produce more impactful or influential publications. It stands to reason that exposure in different countries and research circles will increase a publication’s impact as it naturally reaches a larger audience — perhaps through as simple a mechanism as being shared simultaneously in multiple localities by the various co-authors. This kind of profile is a valuable form of influence in itself. At the same time, the combination and cross-pollination of diverse methods, perspectives and frames of reference that are fostered by international collaboration create a particularly fertile environment for the production of new, influential — and highly cited — ideas, discoveries and innovations.

In this sense, research universities and the urban regions that host them are gateways to global knowledge networks, contributing and drawing benefits in a global process of joint knowledge production and exchange. Actively participating in this network is increasingly important for both the global impact and reputation of research universities and for the local and national prosperity of their host economies. Furthermore, global collaboration is, to a very large extent, a *positive-sum* interaction; it is an amplifying exchange. Collaborating with peers in other countries produces much more than local adaptations of discoveries made elsewhere: it often produces entirely new

discoveries catalysed by the collaboration. Consequently, the size and quality of the global knowledge network are a powerful contributor to local and global prosperity.

I would suggest that there are interesting connections between this insight and the geopolitical dynamics discussed at the beginning of this chapter. A close look at a map of how the United Kingdom voted in the Brexit referendum offers a fascinating insight. Many commentators have pointed out that in most of the UK's major urban regions, a substantial majority voted to remain in the European Union. An examination of voting results by local authority district reveals a nuanced picture, but supports this general observation (Toly, 2017; Becker *et al.*, 2017).

What is less well appreciated is the striking observation that the strength of a region's "remain" vote was especially strongly correlated with the presence of a major research university. Indeed, there is evidence to suggest that the presence of a research-intensive university in a district was a better predictor of the strength of a district's "remain" vote than whether or not the district was part of an urban region.

One explanation for this correlation is that, as noted above, research universities connect their host regions to the world, and vice versa, in ways that bring many benefits to local residents. Hence, these are communities that recognize the value of international engagement because they are deeply embedded in it, from researchers and students to local cultural institutions, firms and industries.

This builds on the growing recognition that the relationship between universities and their host cities is fundamentally symbiotic (Gertler, 2016). It is a partnership that sparks innovation, economic dynamism, cultural vibrancy and urban resiliency. International collaboration is a vital part of this relationship. Complementary forms of knowledge, competence and experience acquired from colleagues in other centres of research and innovation through university collaborations, industry partnerships, faculty and student exchanges, or other forms of international engagement, enrich local communities, stimulate the local production of ideas and innovations, open new avenues of research and inspire creative solutions to unique or shared problems.

Viewed through this lens, international engagement, including collaboration in research, is an invaluable, continually renewable resource, advancing the global standing of research universities, pushing forward the frontiers of knowledge and driving domestic and global prosperity. Recalling the list of the world's leading urban regions by volume of international research collaboration (Figure 2), it is striking — and not at all surprising — that the world's top collaborating urban regions are also among the world's most dynamic metropolitan *economies*.

## EVIDENCE FROM PATENT DENSITY AND VENTURE CAPITAL INVESTMENT

Evidence from the distribution and density of patenting activity, a commonly used (if limited) proxy for innovation, provides further support for the argument that global research collaboration constitutes an increasingly important resource. As with co-publications, international collaboration in patenting is exploding. Since 1980, the number of patent applications filed under the Patent Cooperation Treaty has boomed, rising in 2015 to roughly 75 times its level in 1980. Over the same period, patent applications listing co-inventors from different countries have risen a staggering 30000% — patents involving international collaboration are filed 300 times more often today than they were in 1980 (OECD, 2017).

Where are these co-inventors located? Figure 4 is a heatmap showing geographical variations in patent density around the world, based on US patent data (USPTO, 2107). It is telling that most of the same regions that lead the world in international collaboration on publications — those listed on Figure 2 — also lead the world in patent density. In other words, there is at least circumstantial evidence to suggest that international research collaboration produces favourable conditions for patent activity, perhaps by producing more patentable innovations.

**Figure 4 – Patent Density**



Global patents granted, USPTO. Heatmap by inventor location, 2015.

Evidence from the analysis of venture capital activity complements the picture. In a recent paper called “Rise of the Global Startup City”, my colleagues in the Martin Prosperity Institute at the University of Toronto, Richard Florida



and Karen King, studied the geography of recent venture capital investment data (Florida & King, 2016). Their list of the top 20 metropolitan regions by venture capital includes 10 of the top 20 leading metropolitan regions by international research collaboration, though with some variation in the order and with a couple of significant outliers. Notably, centres of international research collaboration feature prominently in each of the three regions that Florida and King profile — North America, Europe, and Asia. (Intriguingly, significant outliers include several urban regions in India: Mumbai, Delhi and Chennai.)

The overall pattern is clear. It appears that venture capital and other forms of mobile investment seek out these special nodal centres and the opportunities that are signaled by their world-leading research, their deep talent pools *and* their connections with other global centres of knowledge production and innovation through international research collaboration.

Connecting these various strands together, one can view them as comprising a larger cycle: from international collaboration in research to international co-invention and patenting to local venture capital investment. We can think of this as the path from knowledge creation to innovation to commercialization. In a challenging fiscal climate, stimulating this flow, as international research collaboration does, is of obvious value. The source of this stimulation, as I have argued throughout, lies in the fresh and unexpected ideas, perspectives and insights we glean from collaborating with our international peers. International collaboration often forces us to test our assumptions and shift our frames of reference. These are the conditions that spark creativity, discovery and innovation.

## POLICY CONSIDERATIONS

These observations about international collaboration as a resource for cultivating prosperity — locally, nationally and internationally — suggest certain implications for both university leaders and national and sub-national policy-makers. Let me highlight three such considerations. The first concerns university priorities and the imperative to support international research collaboration actively. The second speaks to funding for advanced research — both international and domestic. The third brings the principles and spirit of international collaboration home, with important implications for immigration and higher education policy.

First, if the analysis presented here is correct, then supporting international collaboration between research centres should be a priority for research universities. Certainly, there are many mechanisms that can help achieve this goal, including supporting international collaboration with funding and

administrative and other resources; exploring joint degrees and research projects; promoting student and faculty exchanges; and so on. These sorts of international engagements should not be limited to universities and other institutions of research and education, of course. They could also include private sector actors, civil society and public institutions more generally.

Second, the implications for public policy pertaining to research support are also important — and to some extent counterintuitive. There is no question that direct funding to support international collaboration should be an important objective for research policy. But, at the same time, *domestic* funding for advanced research is also absolutely vital in promoting international research collaboration. In this regard, it is important to recognize, as the evidence examined above clearly shows, that international partners in the development and exchange of knowledge and innovation are not randomly distributed around the globe. Instead, they are most frequently found at leading institutions located in major urban regions. Because “excellence seeks excellence”, in the words of a 2013 editorial in *Nature*, (Adams, 2013), the pool of international collaborators is self-selecting and differentiated by discipline.

Forward-looking governments around the world are increasingly recognizing that, to take advantage of global knowledge networks and benefit from the resources found therein, it is necessary to *participate* actively in these networks. And excellence is required for participation. Consequently, many national and sub-national governments are concentrating their investments strategically in their top research universities, with the goal of building clusters of excellence. Such clusters differentially leverage regional strengths — for instance, strengths in specific university-based research fields, but also in related local industries, services, workforces, and so on.

The recently established Vector Institute in Toronto is an excellent example. Federal and Provincial governments, together with the University of Toronto and local industry partners, have invested some C\$180M to build upon the Toronto region’s research strength in artificial intelligence and machine learning. The goal is to help produce, attract and retain top talent — and further enhance Toronto’s standing as a central node in the emerging global network of extraordinarily promising AI research and development.

Such initiatives take political courage, sustained investment and patience. These are often difficult challenges in democracies whose leaders must routinely face fickle, demanding, divided and impatient electorates. But spreading investments widely and thinly is directly at odds with the global knowledge landscape: it is spiky, not flat (Florida, 2005). To be most effective, to harness the resources of international collaboration, our local research investments must also be spiky.

Third, the same features that make international collaboration such a vital resource make *local* socio-economic, cultural and other kinds of diversity similarly vital resources. Attracting international students and scholars to our institutions, industries and communities fosters a kind of “international collaboration at home”. To be sure, it opens opportunities for the more traditional sense of international collaboration, since these newcomers will bring their professional network contacts with them. But it also illustrates how outstanding scholarship, teaching, learning and innovation thrive only by examining a variety of ideas, discarding those that fail and improving those that work. As is the case with the more common understanding of international collaboration, by inviting the world to our cities, campuses and, especially, our classrooms, we encounter fresh, new ideas, perspectives and approaches that, in turn, inspire understanding and generate breakthroughs in knowledge and innovation. Thus, this kind of local international engagement takes its place in a larger virtuous circle of global collaboration.

As university leaders, we need to make the case for internationalization more forcefully — to our communities and political leaders as much as to our boards of trustees and governors. It can be hard to quantify the value of welcoming international students and scholars to our institutions and cities — though enumerating local startups founded by erstwhile international students or Nobel Prizes won at domestic institutions by international scholars should go a long way. It is sometimes hard to convince policy-makers to make the necessary investments to attract international talent when there are many other investments that seem more obviously beneficial to domestic audiences. But internationalization at home is every bit as valuable a resource as international collaboration with peers abroad, and the two trends are mutually reinforcing.

## CONCLUSION

In today’s world, in which geopolitical forces sometimes work to divide us, a renewed commitment to international collaboration and the understanding, learning, knowledge and innovation that result, can unite us. Indeed, the challenges we face as a global community will require this kind of collaboration, to implement answers as well as discover them. In this sense, international collaboration is a vital resource for advancing both the global standing of our universities and global prosperity itself. As the evidence demonstrates, universities, research institutions and major urban regions around the globe are at the forefront of this effort. Public policy should celebrate this and support it.

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