

EXPATRIATION, A SYSTEMIC BLIND SPOT IN THE CARBON FOOTPRINT OF SCIENCE

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Abstract. In our current academic paradigm, moving abroad to conduct post-doctoral research is the accepted norm. Research institutions rely on a workforce of international post-docs, who seek to prove their suitability for permanent academic positions. In this work, I investigate the post-doctoral period of a researcher's career through the prism of environmental impact through a short survey and my personal experience. I show that the carbon emissions associated with return trips home are not negligible and not in line with the Paris agreement target if made by plane. I discuss that efforts to decrease this carbon footprint associated with expatriation are often invisible and made at the expense of the post doctoral researcher's career and well-being. Moreover, it relies solely on individuals even though it stems from a professional reality. This work highlights the need to start the discussion around the attribution of responsibility for the carbon footprint of academic expatriation, and to question our research model so as to reduce it.

Keywords: Sustainability, Academic Research, Expatriation, Carbon Footprint

1 Introduction

A large part of our current academic research model relies on achievements made by post-doctoral researchers, an academic population that is precarious by nature. Now, during this period in-between the PhD and a hoped-for stable job in research, a strong push for an international professional experience exists in our community. Indeed, an international post-doctoral experience is always viewed positively by a jury, while remaining in France never fails to raise a few eyebrows with colleagues, underlining the risk of such a non-career-oriented choice. While no statistical studies exist on this topic that I know of, the sample of personal contacts I have in astrophysics paints expatriation after the PhD as the norm rather than the exception.

In parallel, there is no denying that expatriation comes with a carbon impact associated with travelling. I've chosen to focus here on travel as the carbon footprint of a person taking the plane will largely be made up of the CO₂ emissions associated with flying. Other parameters, like the energy mix of a country or its political view towards climate change, are beyond the scope of this reflection. The carbon impact of one's expatriation will depend on many factors, such as the distance from the country of origin, the means of travel available, but also the personal convictions of each individual and the trade-offs made between personal and professional life.

In this work, I investigate the post-doctoral period of a researcher's career through the prism of environmental impact. While I draw on my personal experience, I also conducted short interviews with five of my international post-doctoral colleagues, which I present in section 2. This short survey allows me to develop an initial analysis on the reasons behind expatriation (section 3) and its impact on one's carbon emission (section 4). I find that a majority emigrated for professional reasons rather than a genuine desire, and that the generated carbon footprints are either not in line with the Paris agreement target, or reasonable at the expense of the post-doctoral researcher. I then discuss the invisibility of environmental commitment from post doctoral researchers and argue that these CO₂ emissions should be accounted for in the carbon footprint of science, as well as reduced (section 5).

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2 Methodology

To complete my personal experience, I prepared a set of questions that I asked to five expatriated post-doctoral colleagues in astrophysics. My reflection was then based on the feedback of six people (including myself) living in the UK and coming from India, South Africa, Italy, Spain and France (x2). The questions were designed as follows :

- Where are you from?
- Why are you doing a post-doc abroad?
- Do you ultimately want to go back to your country of origin?
- How often do you go back (excluding professional travel) and how?
- Do you think you would travel less or more if you were not an emigrant?

While individual responses are not included in this proceeding, these interviews provided an initial insight into the motivations behind expatriation and an estimate of the carbon footprint of the associated travel (Table 1).

3 Reasons for academic expatriation

Reasons invoked for expatriation are usually of two types : genuine motivation and professional necessity. Both are, of course, not mutually exclusive. The genuine motivation include broadening one's horizons by discovering a new country and a new culture, the desire to acquire an international experience and the possibility to bring back competence to one's home country. Countless sources of motivation for emigration are probably missing here, each unique to any individual. Reasons linked to professional necessity include a lack of post-doctoral positions at a national level and the fierce competition at play for a permanent position. Indeed, an international experience in research (other types of foreign experience are not recognised in my experience) is seen as one of the best ways to prove your suitability as a future researcher, and is mandatory to access permanent positions in some countries.

In the survey I conducted, four out of six people cite professional constraints rather than motivations as the main reason for their decision to emigrate, such as the lack of jobs or the career requirement. One respondent had mainly genuine motivations while also acknowledging that they could not have found a post-doc in their country, and one answered that their emigration was equally motivated by personal and professional considerations. All recognise that the issue is complex and multi-faceted. While such a questionnaire should be extended, this small sample suggests that, at least for a fraction of emigrated postdocs, expatriation is less a personal choice and more of a professional necessity.

4 The carbon footprint of return trips

In parallel, my intuition is that expatriation induces an increased carbon footprint, mainly associated with travel. Indeed, when living abroad, one usually plans return trips to visit close relatives. Additionally, close relatives may also plan visits, but we'll keep this indirect CO₂ emission out of our scope. The annual carbon emission associated with return trips home e_{CO_2} can be calculated through :

$$e_{CO_2} = f \cdot d \cdot e_{CO_2/km}(T) \quad (4.1)$$

where f is the annual frequency of return trips, d is the distance travelled in km and $e_{CO_2/km}(T)$ is the CO₂ emission per km and per person of a given mean of transportation T . The carbon emissions estimated from the survey are presented in Table 1. They were estimated from the Ademe website, and while precise estimates may vary from different sources, they are accurate in order of magnitude. It should be noted that with the exception of France, the destinations were only accessible by air from London, as journeys of more than 24 hours were not considered a reasonable alternative.

From Table 1, we see that plane travel cannot satisfy both the desired frequency of return trips and sustainability goals, i.e the annual emission target of 2 teq CO₂ for an individual in 2050, which includes not only travel but all other aspects of one's life. This 2050 2 teq CO₂ target corresponds to an increase in the global average temperature of 2°C above pre-industrial levels (see IPCC (2022) Fig. SMP4). For reference, the average

Country	f	T	e_{CO_2}	(t eq CO ₂)
Italy	4.5	plane	3.3	
South Africa	1	plane	3.0	
India	1	plane	2.3	
Spain	3.5	plane	1.7	
France	10	train	0.07	
France	2	train	0.02	
Total annual emission target / person set for 2050 (including all aspects of life)			2	

Table 1. CO₂ emissions associated with personal return trips from London, based on the survey presented in section 2. Columns from left to right are the country of origin of the respondents, the annual frequency of travel, the mean of transportation used and the annual CO₂ emission associated, computed from the Ademe website. The last line is the total 2050 annual emission target for an individual based on the Paris agreement, including not only travel but all other aspects of one's life.

annual emission for a French national in 2022 was 9.2 teq CO₂*. By contrast, train travel is sustainable even for regular trips. However, while people from farther away have no choice but to take the plane, people living in countries reachable by train are faced with a hard choice. A return trip from London to the south of France is roughly 460 kg eqCO₂ by plane, but lasts 2 hours (versus 8 hours by train) and costs significantly less than opting for the train. Is travelling sustainably worth the associated loss of time and money?

5 Discussion

5.1 Invisibility of ecological commitment

The reasoning set out in section 3 and 4 leads me to conclude that a commitment to sustainability for a post-doctoral researcher is invisible and made at the expense of the individual. In equation (4.1), all the parameters (d , f and T) are the result of choices made by the post-doctoral researcher, the consequences of which I review in this paragraph.

Table 1 shows that expatriation induces return trips associated with huge carbon emissions if made by plane. These do not include return trips from close relatives visiting, which could also be associated with expatriation and increase its carbon footprint. Therefore, the most impacting sustainable commitment a post-doctoral researcher can make is to settle in a train-reachable destination (reducing d in eq. (4.1)). This is all the more true if the post-doctoral researcher is planning to take frequent return trips due to personal considerations. But such a decision usually comes with sacrifices, like refusing post-doctoral positions located too far away for instance, which may lead to periods of inactivity. However, both staying close in one's home country and periods of unemployment are not easily defended in one's resume.

Another significant decision one can make is to decrease the frequency of their return trips f . The frequency required for one's well being is unique to each individual, depending on their own personal situation. But for all, it could be argued that decreasing f from a given baseline value is done at the expense of the social link with loved ones.

Finally, let us now consider a post-doctoral researcher that has settled in a train-reachable city and that needs to travel back and forth. There can be many reasons for this: the 'two-body problem' when partners live in different places, relatives to look after, children to visit, friends to see, and so on. Choosing to travel by train rather than by plane is a difficult commitment to keep, involving a huge loss of time and money. The more frequent the return trips are, the more this choice will have an impact on one's professional career, due to a reduced quality of life that may affect one's productivity.

Of course the environmental aspect is not the only one considered when making the aforementioned decisions. Wealth, time and personal situations come into play, making the issue a complex and multi-faceted one. But the

*<https://www.statistiques.developpement-durable.gouv.fr/lempreinte-carbone-de-la-france-de-1995-2022>

point of this paragraph remains: plane travel makes expatriation unsustainable and making a sustainable choice (like not emigrating or not too far away, not travelling back which may increase isolation, or only travelling by train which increases fatigue and decreases wealth) is done at the expense of the post-doctoral researcher's well being and career.

5.2 A necessary systemic change

Another key fact is that, currently, the carbon footprint of expatriation solely relies on individuals. Even though it is generated by a professional reality (section 3), emissions associated with emigration (Table 1) do not appear in the carbon evaluation of research units (such as in Knödlseeder et al. 2022; Martin et al. 2022). Yet, if for unknown reasons, plane travel became suddenly totally unavailable, the number of expatriates would probably fall sharply and the academic world would struggle to accommodate the change. This shows just how dependent our system is on international travel, and not just for one-off conferences and workshops. Emigration is also an important aspect of the subject.

The aim of this contribution is to question our research model and to start the discussion around the attribution of responsibility for this carbon footprint associated with academic expatriation. A first step would be to make the carbon footprint of expatriation appear in the carbon footprint of research itself, and discussions on how to achieve that should be led in the community. The long term goal is that when our society decides on how much carbon emissions is acceptable for astrophysical research, international expatriation is well accounted for. How to reduce the necessity for expatriation should also be discussed, both for the well being of postdoctoral researchers and for the sustainability of research. Recognising shorter exchanges of a few months as valid international experiences, for instance, could be an option. They only induce one return trip and are less disruptive to one's life, while still allowing the post-doctoral researcher to develop collaborations and expand horizons.

This proceeding clearly highlights the need for further quantification of the footprint of expatriation through a more extensive survey. One interesting aspect to further investigate is the rebound effect. Would post-doctoral researchers convert their return trips into vacation trips, had they stayed in their home country? When asked, most of the survey participants (4/6) believed that their CO₂ emissions were increased by expatriation. This remains to be verified by a future survey including a control group of non-expatriate individuals. However, even if a rebound effect existed, it would not change the conclusions of this reflection. Any rebound effect would indeed legitimately rely on individuals, while currently they are asked to carry part of the carbon footprint of our academic system.

6 Conclusion

The conclusion of this reflection is, first, that more quantitative research is needed to assess the impact of expatriation on the carbon footprint of science. Preliminary results presented here tend to show that this impact is not negligible. As the academic world relies on expatriation for international experience and building collaborations, it therefore cannot turn a blind eye to this issue and must discuss taking responsibility for at least a part of these CO₂ emissions.

I would like to sincerely thank my colleagues who took the time to answer my questions relating to their travel habits. This proceeding would not have been the same without their input. I'd also like to thank P. Houdayer and J. Eastwood for their comments and proof reading of this proceeding.

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