

# Best Research Practices for Your Quantitative Finance Research Group

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# 1 Introduction

It's early in the morning and the markets are about to open. As an individual trader/investor, or perhaps the manager of a group of traders/investors, you are intensely studying the latest news feed that you think may have an impact on your portfolio.

Amongst the other plethora of tools at your disposal, you have often read about some of the amazing stories from algorithmic trading groups that use quantitative research and computer science approaches instead of human intuition. Using a strict scientific philosophy, these groups have a quantitative research unit that both navigates the vast sea of academic literature and performs research themselves to uncover powerful and profitable strategies.

But how do you perform research? And what are some of the best-recommended practices that you should follow?

In this article, I will describe some of the main aspects of the scientific research process and also recommend some best research practices. The topics that I will cover are literature reviews, writing a research proposal, performing research, writing a paper for publication, useful tools, and, finally, hosting reading groups.

Before I start, I would like to give the following quote, by Savas Dimopolous, a well-known particle physicist, as an encouraging thought to keep in mind during the process:

*“Jumping from failure to failure with undiminished enthusiasm is the big secret to success.”*

Research is rather like a roller coaster ride. On your journey, you will likely experience many wrong turns and dead ends (the troughs of the roller coaster ride) as you try to solve your research problem. This may be discouraging, but I would like to emphasize that this is part and parcel of the research journey.

Being able to solve a difficult research problem, where you find that everything works and fits together like pieces of a jigsaw puzzle (perhaps depending on the significance of the result, a bottle of fine champagne may be obligatory here), is exhilarating. This makes the entire journey for many researchers worthwhile.

Hopefully, by the end of this article, you will have a good idea of the scientific research process, some useful tools that one can use, and to avoid some common pitfalls that can waste your time and resources.

## 2 Research Process

After some thinking, you have now identified an area of quantitative research that you think could lead to lucrative strategies or where your group may contribute to publishable results.

### 2.1 Literature Reviews

The first step is to understand the academic literature on the subject. Academics and industry experts will publish their research in research journals (it is worth mentioning that the landscape of published papers on a particular topic can be vast, with only a percentage of papers being profitable to implement in practice - user discretion is advised!)<sup>1</sup>.

As with many instances, the saying “*garbage in, garbage out*” is useful to keep in mind here. Basing your research on poor quality research (which can have ill-motivated conclusions, for example) can be a recipe for disaster for your portfolio or if you are interested in publishing papers, lead to erroneous results! To study high-quality research, you should subscribe to high-impact journals within your chosen field. These journals will have distinguished reputations and a history of quality publications vetted by peer review (which is performed by established academic and industry experts). The impact or quality can be determined by looking at certain metrics such as its impact factor, the researchers that publish in these journals, etc. For more information, take a look at the article [How to Determine the Quality of a Journal](#).

Once the relevant high-impact journals have been identified, you are ready to perform a detailed literature review of your topic of interest. The literature review should start by understanding the current state-of-the-art developments in your topic of interest. Additionally, if you are also interested in publishing papers yourself, this should give you an indication of the type of open problems being studied by other researchers in the field and where you or your group may start making contributions.

To understand the results in your review of the current literature, you should try to replicate the author’s results. Any quality journal publication(s) will have a decent set of references that they refer to in their paper. If you get stuck trying to understand their results, diving into their reference list is a great approach to better understanding the author’s results!

I would also highly recommend looking at review papers that provide excellent overviews of the current research progress in the field. These papers are especially helpful if you are an inexperienced researcher(s) (for experienced researchers in the field, these papers are great to refer to if you need to recall

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<sup>1</sup>It is also worth noting that these research journals often have pricey subscription fees to access their repositories.

specific developments or concepts).

In addition to the most recent papers published in the journals, one may also note the existence of “*landmark papers*”. These papers can be considered huge breakthroughs in a field (for example, the celebrated Black-Scholes model for the pricing of options, published in (Black and Scholes, 1973)) and decades of future research is generated from these papers. Similar to the saying “*all roads lead to Rome*”, you may find that following the trail of citations from one paper to another leads to a landmark paper. As such, they serve as “signposts” within the vast landscape of research papers (landmark papers are often characterized by massive citation counts; for example, the previously mentioned paper (Black and Scholes, 1973) has approximately 43 500 citations at the time of writing this article). Understanding these landmark papers is highly worthwhile and serves to give context and understanding to current research in the community.

At the end of the literature review, you should have a very complete picture of the current topic that you are interested in. At this point, you may be able to identify possible research questions (this can be open known problems in the field or research questions identified by oneself) that can be answered and published or have identified a strategy that you have determined to be profitable. It is also perhaps worth noting that the literature review may take several months (maybe even more) to perform, depending on your knowledge of the field and the difficulty of the topic.

Finally, as some examples of highly recommended quantitative finance journals used by Hudson & Thames, see the journals from Portfolio Management Research. In particular, we enjoy the Journal of Financial Data Science and the Journal of Portfolio Management.

## 2.2 Research Question

Now that you (hopefully) have a deep understanding of your chosen research topic, you have identified a research problem that you believe you and/or your team can solve.

One of the most important aspects of performing research is formulating a well-defined *research question*. The research question should have no ambiguity or vagueness to it. It should be clearly stated with all terms/words in the question well-defined. A poorly defined research question can be a waste of time and resources.

For example, suppose we are presented with the following research question:

*Is there a higher power in the universe?*

Well, what exactly is meant by a “*higher power*”? It is a well-known fact that there are many different and often contradictory relative notions of a higher

power(s) amongst the many different human cultures. As far as research terms go, it is therefore clearly ill-defined and two people reading the research question may have very different ideas of what is meant by a higher power.

As another example, consider the following question:

*Has pairs trading been profitable in the past 5 years?*

Although the terms are better defined than our previous question, this question is too simple in that it can be answered with a yes/no response. There may be many important and subtle nuances to this topic that will not be captured by this question since it is of a yes/no type. A better question is:

*How has high-frequency trading affected the copular approach to pairs trading on US-listed equities in the last 5 years?*

This question will capture more of the complex and subtle aspects of pairs trading on US-listed equities than the previous question. Questions of this type (as opposed to yes/no type research questions) also have the benefit of possibly leading to many years of further research and publications as one discovers further important details.

Moving on, the research question should also be something that is “*answerable*”. By this, I mean that the research question is of a sufficient level to be interesting/useful for the community, but not at a level such that it is impossibly difficult to answer (for example, our question above concerning the existence of a higher power is one that humanity has wrestled with for millennia without a concrete solution that is agreed upon by everyone). As researchers, we may have a dream to answer the most profound questions in our fields, but this may be too difficult with our current understanding and tools. Of course, trying to answer a too difficult research question can be a waste of time that leads to no interesting new results.

Finally, being able to find a worthwhile research question that is answerable is something of an artistic ability that consists of a researcher’s experience in the field and whether they have good scientific intuition and an eye for seeing what other people might not see. For more information on writing a good research question, see the following articles

- How to Write a Research Question: Types, Steps, and Examples
- Research Tutorial: Good and Bad Research Questions
- How to Write a Hypothesis or Research Question
- Examples of Good and Bad Research Questions

## 2.3 Research Proposal

The next step is to write a *research proposal*. The research proposal helps to formalize the problem and plans out the research approach. As such, it is also a helpful document to refer back to at a later time if needed or for a new researcher to read when they join the research team. In academic and industry settings, the research proposal is used for approval by a research committee (who will decide on the feasibility of the research) and for funding applications.

Broadly, a research proposal consists of the following sections:

- Title
- Introduction (or Background)
- Research Question or Hypothesis
- Methodology
- References

The Title should be a good description that captures the essence of your proposed research.

In the Introduction (also sometimes called the Background) section, you will give a detailed description of the background theory which comes from the literature review discussed in Section 2.1. It may be a highly technical discussion of a specific part of the literature review that is relevant to the research question.

In this section, you will also provide strong motivation for your proposed research. This can include how your research relates or answers current questions in the field.

The Research Question (also referred to as the Hypothesis) section is the formal statement of the research question discussed previously (see Section 2.2). As mentioned, it should be a well-defined and understood question.

In the Methodology section, you will discuss your approach to solving your research question. This will include the types of methods or research strategies that you will use to try to answer your question. For example, if your project is data-driven, you can discuss your approaches to collecting the needed data and the data analysis you plan to perform.

The References section contains the references to papers cited throughout the research proposal. It should be complete in that it captures the important publications relevant to your proposed research. The references should be cited in the appropriate format, such as the Harvard-style of referencing, and provide

all the necessary information such that the paper can be found by another researcher.

There may be slight deviations to the form of the research proposal I have discussed above but this is sufficient to provide a working framework for anyone interested in research. For more detailed discussions of writing a research proposal, see for example

- How to Prepare a Research Proposal
- How to Write Your Research Proposal

## 2.4 Research (Answering the Research Question)

Once your research question has been finalized and the research proposal has been written, you can proceed to answer the research question using the methods described in your research proposal.

An important part of quantitative research is academic rigor <sup>2</sup>. Similar to the discussion about the research question, ambiguity in any results that you find should be eliminated as this can be a source of time wastage and even allow errors/misunderstandings to creep in. Also, assumptions should be minimized as much as possible or should, at least, be well-motivated as to why the assumptions are made.

Next, a healthy level of skepticism should always be directed toward your results! Results should be thoroughly checked from as many different angles as possible. This may be done through numerical checks, studying the result for certain well-known special cases (in other words, does your result reduce to special known cases in the published literature), etc. This allows you to be highly confident of your results (and can even be presented as further evidence of the correctness of your result).

As a bonus, in the attempt to answer the research question, new avenues of possible research are often opened which provides a great source for further publications.

Once your results are finalized, you can present them to an audience of fellow researchers. It is fantastic marketing for your research if you can present it at a recognized key research conference (preferably, you also have a paper published already, which is something I will discuss in the next section).

It is a common practice amongst researchers to reach out to other experts in their field for comments on their results. These may be experts that have

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<sup>2</sup>A well-known saying, by Ellis Cooper, to keep in mind: “Rigor cleans the window through which intuition shines.”

written important papers on which your research is based. Likely, thanks to their deep experience in their research fields, they will be able to pick up if something doesn't sound right in your results or be able to give useful advice for overcoming technical barriers encountered during your research.

Finally, being able to discuss your research with fellow researchers can also provide a source of further research through collaborations.

### 3 Writing and Publishing a Paper

Once the results are finalized, you can proceed to publish your results and share them with the world. An excellent reference on writing a scientific research paper, which offers many tips and addresses common pitfalls, is given in the article *11 Steps to Structuring a Science Paper Editors Will Take Seriously*.

For quantitative research, I highly recommend writing in  $\text{\LaTeX}$ , which is a powerful typesetting system that offers great versatility and control, especially when writing long and complicated equations. The chances are that, if you are reading a quantitative research paper, it was typed in  $\text{\LaTeX}$ .

Next, you will have identified a research journal for publication. Each journal will have its specifications on the format and layout of the paper which you need to adhere to. Once you have sent your paper to the journal, it will be reviewed by a panel of referees that consists of academic and industry experts (also referred to as peer-review). Their job is to carefully evaluate your results for correctness and determine if it is up to the standards of the journal. Once the panel has reviewed your paper, they may make some suggestions for changes and will give you confirmation on whether your paper has been accepted for publication<sup>3</sup>.

Typically, a journal paper will have the following outline (but this may depend on each journal and the type of paper you are writing, i.e. is it a paper focused on theoretical/mathematical results or is it very experimental with lots of data collection and analysis, etc):

- Title
- Abstract
- Introduction
- Methods
- Results

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<sup>3</sup>It is perhaps worth noting that there are also fraudulent "predatory journals" out there - so be careful! See Beall's List of Potential Predatory Journals and Publishers for a list of potential predatory journals.



- Discussion
- Conclusion
- References

The Title should be brief, concise, and descriptive. It should broadly capture the content of your paper.

Imagine if a researcher was looking through a repository of papers for a specific topic on which you happened to have published a paper. In their search, they will be looking through many different titles of papers. If your paper has a title that is not sufficiently descriptive, researchers may end up glossing over it and your hard-earned research results might not get the attention it warrants from the community.

The Abstract is a brief description of the results in your paper and provides further context to your paper for any prospective reader. Continuing from the discussion of the title, suppose a researcher has seen the title of your paper (which is hopefully well-chosen) and is curious. The next thing they will read is your abstract, so the abstract must provide the necessary results of your paper in a brief and concise manner (it should be a paragraph).

The Introduction section sets the stage for your results. It will describe the necessary background theory for your results by discussing the key papers that were important to your research results. As such, it should also give readers a good indication of how your results fit into the current research being performed in your research area. The majority of your references to other papers will be made here.

In the Methods section, you will describe your approach to solving your research problem. This should have enough detail so that another researcher may follow your approach and reproduce your results. If you are using established methods, then a broad description of the method and a reference pointing to the original paper, for more details, should be sufficient.

In the Results section, you can finally present your hard-earned research results. Present your results concisely and clearly.

Then, in the Discussion section (this may often be combined into a single section with your results instead of two separate sections), you will give a discussion on the meaning of your results. As spelled out in above mentioned article, it is the most important section to get right and a large number of papers are rejected by the journal because this section is too weak. Also, you should avoid statements that go beyond what your results can support and using vague/unspecific expressions (such as “*higher* temperature”). Instead, use quantitative descriptions! As always, be clear and concise; colloquially-used

words can lead to ambiguity.

For the Conclusion section, you should not repeat your results (this is a common error that often is made). Instead, you should provide clear scientific justification for your results. In addition, you can include further extensions and future research avenues stemming from the results you found.

Finally, the References section will contain the bibliography of all the papers you cited in the paper. The number of references should be sufficient to cover the things you mention in the text but should not be overly inflated with unnecessary references. Care should also be taken to ensure the correct format of the citations and that small details (such as the spelling of authors' names and surnames) are correct. Fine details are important here.

The above sections are a good general template to follow for writing a paper, although you should ultimately follow the specifications required by your target journal. There may be some extra small sections that can be seen in published papers. For example, the author's will often include an Acknowledgements section thanking other researchers if they had useful discussions with them or thanking their funding agencies; The authors may also include an Appendix section with further calculations, data, and/or figures.

Wrapping things up, your paper should display high-quality writing. Importantly, you should use excellent grammar (I highly recommend Grammarly as a good option for checking grammar) and ensure spelling checks. As mentioned several times, the paper should be written clearly and concisely. Avoid unnecessary vague words since you should aim to be precise about statements. There should be a logical flow in how the material is presented, starting with an introduction that leads up the results, a discussion around the results, and finally a conclusion. Any assumptions made during your research should be clearly stated and motivated in the paper.

As a goal, you want to publish the result in a high-impact journal (see the discussion in Section 2.1 concerning journals). These journals have high standards for accepting publications, which is a good thing. Furthermore, as already mentioned, presenting the paper at key conferences is a great way for the paper to gain further exposure within the community and to foster future collaborations with other researchers.

## 4 Recommended Tools

As you may have wondered, there is a fine list of tools that can help simplify things during your research process. In this section, I will mention some of our favourite tools.

## 4.1 Writing

### 4.1.1 L<sup>A</sup>T<sub>E</sub>X

As mentioned in Section 3, when writing quantitative papers, using L<sup>A</sup>T<sub>E</sub>X (LaTeX) is the easiest. If you are a first time user, L<sup>A</sup>T<sub>E</sub>X is quite easy to pick up and, since there are many L<sup>A</sup>T<sub>E</sub>X users, there are many tutorials and solutions if you encounter problems.

I highly recommend Overleaf, which is an online TeX editor. It has some fantastic ease-of-use aspects since it requires no installation (it runs from your browser) and package management is taken care of by Overleaf (you can simply call the required package in the preamble, no need to install it locally on your machine). Additionally, if you are part of a group of collaborators, you can have several people edit a single document (such as the paper you wish to publish).

For publication purposes, journals often have a L<sup>A</sup>T<sub>E</sub>X template, complete with their style specifications already in place, that you can use and these templates can often be found in Overleaf's impressive repository (which has many other templates that you may find useful). As a plus, your work is also saved on their cloud and can be accessed from anywhere, so long if you have an internet connection.

Alternatively, if you have difficulties with internet connectivity or wish to create and edit L<sup>A</sup>T<sub>E</sub>X documents locally on your machine, then MiKTeX, which is free and open-source, is a great option for Windows, Linux, and macOS.

### 4.1.2 Mendeley

As you are performing your literature review, you will likely read many different papers from different sources. Being able to efficiently manage these papers and reference them is, therefore, a must. That is where Mendeley comes in.

It is a well-known reference manager that neatly stores and organizes your research papers as well as generates references. Often you will need to refer back to a paper. Once stored on Mendeley, searching for it amongst your library of papers and generating a reference (for example, a BibTeX entry, which is a L<sup>A</sup>T<sub>E</sub>X referencing tool that I also recommend) for the paper becomes a breeze.

Mendeley is also free to use but does also offer paid premium packages if you need extra features.

### 4.1.3 ZoteroBib

ZoteroBib is also a great bibliography generator worth mentioning. It is free to use and does not require any installation or an account. Impressively, it sup-

ports over 9000 different citation styles!

Zoterobib is also easy to use: all you need is a piece of key information such as the ISBN, DOI, or arXiv ID. If you are viewing a publication from a journal's webpage, you can also copy the webpage URL and ZoteroBib will try to automatically compile the paper's bibliography information.

Finally, ZoteroBib can output the bibliography information in several formats including BibTeX or RIS.

## **4.2 Finding Research Publications**

For your literature review, having the right set of tools for efficiently finding research papers is important. In this section, I will recommend some great search tools, as well as online repositories, that may help you find exactly the paper you need.

### **4.2.1 Google Scholar**

As a first attempt at finding a paper(s), perhaps the best option is Google Scholar.

Instead of searching web page content like its parent search engine Google, Google Scholar will search (using the keywords you entered) through the research literature, such as books, articles, and theses from a wide range of sources such as academic publishers, universities, and online repositories.

In the search results, it gives some useful information beyond the title of each paper, such as a brief description of the paper (where your keywords are mentioned) as well as its number of citations, and has some useful features, such as a reading list to save papers for later.

Although you are very likely to find interesting papers from Google Scholar, it is (like any tool) not completely flawless and it may not always find papers relevant to your search. Therefore, you may need to use additional tools.

### **4.2.2 EThOS**

In case you do not find anything interesting on Google Scholar, EThOS is another great tool that offers a vast repository of over 500 000 doctoral theses from UK institutions.

It is freely accessible for anyone but you do need to create an account to download a thesis (alternatively, it also provides a link to the author's home institution which may offer downloading without the need to create an account).

If you know of a thesis from the UK but cannot find it on EThOS, then you can submit a request form and EThOS will try to find it and upload it to there repository.

### **4.2.3 arXiv**

Another vast online repository is the preprint server arXiv, created by the physicist Paul Ginsparg.

Researchers will publish their papers in both the arXiv and a target journal. This is because the process of publishing in a journal takes time and arXiv therefore provides quick access to the latest research papers. It should be noted that papers on arXiv itself is not peer-reviewed.

In terms of access, it allows open access for the public to download any paper, although if you are interested in submitting papers to the arXiv, there is a short vetting process to go through (for example, you may need an endorsement).

A great feature of the arXiv is its daily listings of new research papers submitted to its repository (see for example its latest quantitative finance submissions).

### **4.2.4 Connected Papers**

For a more visual approach, see Connected Papers which constructs a visual graph of papers relevant to a researcher's work.

The graph is constructed by analysing approximately 50 000 papers and using co-citation and bibliographic coupling as a metric to measure similarity between papers.

Once you search for paper (by entering a paper identifier), the graph is constructed in a few seconds and you see a web of papers as nodes with connections between other nodes. Each paper has a detailed corresponding description (found by hovering your pointer over a node), with additional information such as the authors and citation count.

## **4.3 Learning**

Often, during your journey of studying a research area, you will find that you need some specific background skills or knowledge. This may, for example, be an area of mathematics (such as stochastic calculus which is used quite heavily in topics such as statistical arbitrage) that is used in a research paper.

An important skill is to quickly and efficiently pick up the necessary background knowledge and researchers tend to be quite good in this regard.

In this section, I will recommend some useful online resources for quickly picking background knowledge. Typically, these recommendations should also be supplemented by the relevant textbooks.

#### **4.3.1 Youtube**

As most people are certainly aware, there is a wealth of freely available lectures and presentations on Youtube covering many different background topics. As a bonus, some lectures even allow access to their practice tutorials, which is one of the best ways to learn a quantitative subject.

For example, a great lecture series by MIT OpenCourseWare is Topics in Mathematics with Applications in Finance which covers many useful background topics such as stochastic calculus, time series analysis, portfolio theory, etc. The problem sets, as well as other resources, can also be found at the MIT OpenCourseWare page for this lecture series.

#### **4.3.2 MOOCs**

There is also a vast collection of online MOOCs (Massive Open Online Courses, such as Coursera and edX, for example).

The course material is often made freely accessible to the public but for exercise grading and a certificate, you will need to pay for the course (students can apply for financial aid if needed). The courses typically provide several weeks of lectures accompanied with tutorials and projects. These courses are well set up for people working full time and can be conveniently completed in your spare time.

As examples, a great course for upskilling your programming skills is Data Structures and Algorithms Specialization and, for machine learning, see Andy Ngo's famous Machine Learning Course (for more advanced users, see also his Deep Learning Specialization).

## **5 Hosting Reading Groups**

Finally, to end this article, I would suggest forming a regular reading group (also referred to as a journal club) amongst your research peers. Since it is very difficult to cover every new development in your field, a reading group is a great way of keeping up to date with things beyond your current research. It is a staple of many research departments.

Depending on the number of participants, this typically takes place once a week where someone will present an interesting paper that they are currently studying. The choice of meeting day will depend on each person's preferences but, if possible, I would suggest a Friday afternoon (perhaps at about 14:00 pm, but this would also depend on the time zones of the participants) since Friday afternoons tend to be more relaxed and open than the rest of the weekdays.

Since you may want to include people from other locations, meeting in person may be difficult. Thankfully, it is very easy to set up a Zoom meeting so that your peers from different geographic locations can attend the reading group too. Alternatively, you may record the meeting and upload it to a private Youtube account.

If coordinating a meeting time is difficult, another alternative is to have a "lunch and learn" session. The idea would be the same as before (in that a participant presents an interesting paper) except this is done during everyone's lunch break.

An excellent tip, from the article *How to Lead a Technical Reading group*, is to facilitate discussion during the reading group. Your goal is to ensure that, by the end of the meeting, everyone has a good understanding of the material presented. There should therefore also be ample time for questions and discussions.

Perhaps the biggest difficulty in hosting a reading group is to ensure that it doesn't lose steam. To help circumvent this, the mentioned article recommends that everyone in the group contributes to the ideas and running of the group. For example, you may want to set a scope for the reading group and getting the participants involved in this from the beginning is great for engagement. As another example, you can appoint a member with the task of consistently advertising the following week's discussion topic. The member will provide the presenter's name and an abstract of the topic/paper to be discussed that is then sent to an email group. In this way, people will remain committed and there will be sufficiently interesting topics to keep the reading group from fizzling out.

## 6 Conclusion

All in all, I hope that this article has given you a good overview of the research process, publishing papers, and some of the useful tools available.

In case you would like to know more on the topics I have touched on in this article, I encourage you to follow some of the excellent references provided below.

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