

# **PAUL AND DOMINIC'S GUIDE TO GETTING A QUANT JOB**

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## Welcome

We've written this guide for people looking for their first or second job in Quantitative Finance. The idea is that by the end of it you will know the things that many people wish they'd known a couple of years earlier. P&D is a headhunting firm, so we have a keen interest in helping people do well when they try for jobs in banking. This is a collection of things we've learned about the process, the skills you need and how to present them. However, quantitative finance is a broad field and almost nothing we can say applies to every situation. This guide should help you, but we're always available online to talk about your individual case. Either through the website [www.PaulDominic.com](http://www.PaulDominic.com), or directly as [Dominic@PaulDominic.com](mailto:Dominic@PaulDominic.com) or [Paul@PaulDominic.com](mailto:Paul@PaulDominic.com).

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## Introduction

If the recruitment process is working well, then the people seen by the bank will be roughly the same quality (however they define that) and from comparable backgrounds. The people you are competing with typically have similar qualifications and are usually quite smart. The first thing this should tell you is that you need to stand out in order to win. Being headhunters we speak to a lot of recruiting managers and we find that the difference between the one who got the job and the person who came second is often very small for the employer, but obviously rather more important for you.

Even with that filtering, there is a still quite a wide spread between the people seen by the interviewers. Interviewing is largely the extraction of a signal from very noisy data and so one person may be easily better than another but for various reasons, this fact may be missed. It is of course also true that some people get hired who are really not as good as they appear. There is profound sampling error. An interview is a relatively small set of samples taken over a short period and good people do experience off-days. This is one area where later we give some tips on how to reduce the chances of that happening to you.

### Understand the process

Interviewing people is a major industry all by itself; multiply the number of applicants by the number of interviews they attend and you sometimes wonder how any useful work ever gets done. Certainly this thought occurs to interviewers on a regular basis. They want it to end. Although it is important to get the right people almost no one enjoys the process. This is made worse by the fact that more than 80% of the work is wasted on those you never hire. The record (as far as we know) is one bank who interviewed *thirty seven* people before they called us in and by the end they were getting more than a little bit tired of it all.

This means that although you may feel uncomfortable in the interview, it's worth remembering that the interviewer might well want to be somewhere else as well. Anything you can do to make their life easier is helpful. Not only does that mean being as pleasant as possible, but also turning up at a good time and seeming like the sort of person they want to work with.

### What you need to prove

- *You are smart.* This will often take the form not only of maths questions, but also brain teasers. Your CV makes a lot of promises, you need to deliver on them. It follows that anything you put on your CV is a potential source of interview questions.
- *You can work with people.* Smart is important, but you can expect to spend more time with the people you work with than who you sleep with, so they would prefer to hire someone with whom they can get on. Most of your academic work has of course been on your own, so this is an area where many entry level people can seem weak.
- *You can get things done.* In exams you can get good marks for nearly completing a problem, or having the right idea and making a small error. That doesn't work so well in finance where "nearly right" can be really quite unpleasant.
- *You can manage yourself and your time.* You're not a factory worker assembling Barbie dolls. Your output cannot easily be measured and good managers don't micro manage quants. Note we do not say all managers are good, hence the "My Manager Wants Me Dead" series on Dominic's Blog.
- Being able to point to examples of where you worked alone without guidance or invasive management will help your case greatly.
- *You are committed to this line of work.* This may sound like a strange thing to have to demonstrate. But more than once we've had feedback from managers that the candidate seemed to have drifted into applying for a quant job with little idea of what the work was like, or what they could offer an employer.

### How to prove it

Hopefully they've read your CV, but this is only a very short summary. So as well as answering questions, it is good to be able to show examples of where you've applied a skill, or where you've coped with a particular situation. This bit of preparation before you go for interview is well worth the time, and does far more for your chances than trying to cram in bits of maths and payoff diagrams the night before.

Throughout the guide we emphasise the competitive nature of the market these days. When Paul Wilmott worked on starting a university mathematical finance course it was rare for a university to have such a thing. Now it is rare for them *not* to have at least one. As far as we can tell, the University of London alone has something like 20 separate Masters in Finance programmes.

Emanuel Derman's autobiography *My Life As A Quant* is compulsory reading for anyone wanting to move into this field. The market for quants is of course much larger than when Derman started working as a quant, but the supply side has increased at least as fast. Thus you must not also show yourself to be smart, but also more useful than the others going for the same job.

### Kissing frogs

Like trying to find a prince by kissing frogs, you have to accept that it is rare for your first attempt to succeed, so you must be prepared for the long haul and to pursue multiple options at the same time. This means applying to several banks and not being deterred by failure to get into a particular organisation. This cuts both ways. Just because a bank says “no” once, doesn’t mean it despises you, indeed it is far from unknown for them not to check whether you applied before, so it can be worth applying to the same bank later. However, if you are applying to two distinct parts of the same large bank, it is worth letting them know. They will not be pleased if you didn’t mention it to them, since it can be embarrassing and that’s not a positive feeling to cause in someone who might employ you.

You need to work out how committed you are to a particular sector of the market. Some people find that they prefer fixed income to equity products, others feel that commodities offer the best opportunities for them. Some managers feel that you should decide at this early stage which product class should be your home. This is frankly a bit unrealistic. A newbie simply doesn’t have the information to make that sort of decision and of course anyone who’s smart enough to predict the relative success of several business areas of the next few decades is going to end up ruling the world anyway. But just because it is not a reasonable thing to demand, doesn’t mean that some managers don’t think that way.

You don’t have to make up your mind yet, but when you accept an offer you are making some other doors quite hard to open in future. It is possible to move between the main types of business area, but not easy and harder still to do it from a position of strength in your later career. Thus getting a job is a competitive international sport, where it is not enough to succeed. Others must fail.

Some people do have an excessive preference for a given bank, often Goldman Sachs. This is of course a fine ambition, and they do make great big piles of money. But that does not mean they want you, and discovering this when you’ve spent a lot of time on getting a job there, but made no attempt to hedge that position can have mildly unpleasant effects on your career.

Also the best job for *you* may not be at your target bank. They may offer you a role considerably below your level. Of course it may be worth your while working in a lower quality area to get into the one you want, but be aware that moving areas in a bank is really quite hard. If you’re good your current manager does not want to lose you, and if your unhappiness with your current role impacts your work, you’re not that attractive to your target manager. Some managers are entirely selfish on this point, and will use the bonus mechanism, and anything else they have available to keep you in your current position.

Bottom line is that if it were easy and efficient to change roles within a bank without having to leave, there would be a lot of poverty stricken headhunters.

### When to Apply

The time to start the process is as soon as you know roughly when you are going to be on the market. Sooner is almost always better than later.

Our record from receipt of a candidate's CV to a job offer is just over a week, but we also set up one quant in his job a whole year before he's expected to start at the bank. These are extremes, but they illustrate that the process is flexible, yet hard to timescale with any precision.

An increasing number of firms have structured training programmes for quants. Because they have fixed dates, a late application means you either have to wait, or miss out on joining the programme. These should not be confused with the vastly more common graduate training given to other types of workers in the bank.

### Internships

Banks see most internships as an extended interview, allowing you and them to see whether you are good for each other. Most of these are handled as bulk processing. This means application through bank websites and automated systems. If you pass the first simplistic filter then you may actually get to meet a human being. This is the area where applying as soon as possible is very much in your interest. It is not enough to get your application in by the end of the period, many banks work it by going through applications until they are full, then stopping. They rarely admit this on their web site.

Thus the vast bulk of internships are not done through headhunters, and most HHs don't handle them at all. P&D do a few, where a specific business unit wants a particular skill set.

Your first interview will not be as good as your last. As you will read in the interview section there are distinct "interview skills". Thus your early interviews have less value than your later ones and if you suspect that your face to face interaction is not 100%, you might as well go for some interviews to gain confidence and make mistakes that matter less.

It is of course possible that when you apply, they say that you're too early. Fine, then you can apply later. You should not assume that they will keep your CV. A combination of data protection laws, "entertaining" application management systems and the sheer volume of job seekers mean the odds are that your CV will not be sucked into the process when it starts.

Applying for a job does not have a high cost. The real cost is when you don't apply early enough and miss it. Every single day, jobs you might have wanted are being consumed by people you are competing with. Obviously the odds are against you getting them, but you are interested in maximizing the area under the curve, as well as the chance of getting a job.

There seems to be a clustering of PhD defences in the lead up to Christmas and it is tempting to apply after your PhD. That's wrong on a couple of counts. Firstly the bonus round is going on so employers are distracted and Christmas causes a lot of processes simply to stop. Also you are competing with the others who wait for PhD completion and that doesn't help your chances.

You've also missed the jobs that went out whilst you were waiting and they're not coming back.

### Apply before finishing your PhD

Masters programmes typically have a very fixed end date, but most PhDs do not. It is also the case that the final PhD write up is observed to be at least a little non-deterministic. It is best to finish your PhD before starting work, but typically not a good idea to try working on your write up and do a hard new job at the same time.

Apart from the stress of serving two masters, a critical thing to your career is the early impressions your employer makes of you. The quality and type of work you get given is a function of what they think you can do, so you want to be 100% committed to doing early work well. This conflicts with the “finishing touches” to your PhD and given that your first job may well leave you tired, the PhD will drag on for longer, all the time reducing the impact you’re making on your new boss.

### When to Apply if you’re doing a Masters

Now.

Apply early, apply often. Some employers are quite happy to be flexible about people studying masters part time and although they are a minority, they are worth grabbing whilst you can. If you’re doing a full time then if you haven’t started sending out your CV, you should do it now. You may be also able to wangle an internship. If you’re reading this right at the start of the year, then a good % of employers or headhunters will either ignore you or tell you to apply later. But, at the risk of repeating ourselves, as long as the probabilities remain  $\geq 0$  every time you try, you increase your chances.

Because masters programmes usually track undergraduate terms, your classmates (or competitors as we like to call them), will all be hitting the market at the same time. They will be going for the same set of jobs and unless you are easily the smartest person in your year, that’s a bad thing.

## Writing a CV

A CV is not merely a passive instrument that simply tells a recruiter why he should interview you, it also helps set the agenda for the questions you will be asked when they meet you. Thus it is important to choose what you disclose as a balance between what you think they want and the areas in which you are confident answering questions.

As there are a lot more applicants than jobs, the early stages are optimised to filter out those who stand no chance of getting in. Thus you must take considerable care to make sure you don't fail at an early stage because of trivial errors. It is hard to tell from a two- or three-page CV whether you have the right stuff to be an ace quant, but little defects in spelling, grammar, or even layout can do more harm than you might think.

Although at P&D we've actually done this stuff, it is often the case that CVs are filtered by people with wildly variable skills in finance. Often they resort to looking for keywords. Thus you should not rely upon them working out that if you have done subject X, you must have skills Y and Z. If you believe those skills are critical for this job, then make sure this can easily be spotted. Given that many HHs and others who look at your CV have absolutely no quant skills of any kind, they do pick up on the "feel" of a CV, which includes quality of English. This is particularly important if your CV gives them grounds for thinking that English is not your first language. The legal issues are such that no one is likely to ask, "you're foreign, can you speak English properly?", which unfortunately means that they may silently and unfairly judge you.

Read the job specification carefully and if they specifically ask for a skill or experience, then include whatever you can to illustrate your strengths. If you believe a particular skill is critical then you should mention it in your covering letter as well (or if you believe the headhunter is particularly dim). We could name names on the "dim" bit, but that would be cruel.

### Make sure you can be contacted

You absolutely must make sure your contact details are reliable and that you regularly monitor the relevant email account(s) and telephones. It is sad when someone's CV show great promise, but they don't respond in time to be interviewed. You have no idea how frustrating it is for us, but it's far worse for you. This does happen. If you are at university, be aware that your current email address may stop working soon after you complete your course. GMail is to be preferred over Yahoo or AOL for personal email addresses.

Leave AOL. Do it now.

### Get your CV checked

Have your CV and covering letter proof read by a native English speaker, not just someone who has been taught English. This is important because people really do judge your ability by how you express yourself. The first part of your application is that someone will be trying to read your CV and if it looks poor then that hurts you. Quant Finance is an international sport, with speakers of every language and the ability to communicate difficult ideas is important and if you can't get the name of your university correct, it makes the interviewer wonder if you can explain your views on jump diffusion or copulas. Yes, people do get their university name wrong, which is nearly impressive in a scary sort of way.

### The Klingon CV

Sadly, it is usually the case that most head hunters have absolutely no idea what most of your CV means and from their perspective it may as well be written in colloquial Klingon. Between you and the hiring managers it will pass through the hands of headhunters, human resources, secretaries and if you're really lucky, an intern who has some vague idea that "Mean Reversion" is not a film starring Clint Eastwood. Thus they will judge your ability in mathematical finance based upon buzzword matching and your adequacy at English. That's unfair isn't it? Life is unfair, live with it.

At P&D we look below the surface, but the harder you make it for us, the more you reduce your chances and even for us it is worrying if someone puts "good communication skills" and writes text that makes the Teletubbies sound like Shakespeare. You should also know that CVs use a particular style of English, which is subtly different from the one you learned in school. This **must** be done right. In your first year alone you will cost your bank more than a very nice Porsche. Would you spend 100,000 on "high specification" goods where the advert for them was rubbish? Do you think Rolex adverts spell "chronograph" incorrectly?

(No, we didn't have to look it up, and neither of us wears a Rolex)

Your CV is an advert for a high-value product.

*You.*

On the Wilmott forums recently I read of one person who applied to Goldman Sachs, but who got his dates of employment wrong. It could mean he mistyped, it could mean that he was tired or distracted whilst typing, other things may be true or false. One thing that is 100% true is that he didn't get hired.

Looking at CVs we see this is not as rare as it should be. Several % of people have dates that do not look right and that does worry us. Of course, if you've done a part time Masters in Finance, it may well be that you appear to be doing two things at the same time, but it is worth putting in a short explanation. Short is the important word, as we find that long explanations never sound as convincing.

### Covering letter

In your covering email, mention where you saw the ad. This helps the recruiter in determining the impact of various ads/media and shows him/her that you have a good business sense. Also try to show a little enthusiasm and feel free to mention a couple of things you feel are of most interest to the recruiter. CVs and covering letters aren't really read, they are skimmed through and if you have an important thing to say, this is a chance to say it again.

### Fonts and layout

Some things on your CV are important and **you may** want to draw their **attention** to them. Your

eye was drawn to this part, but **Do not** do this excessively. It is **really irritating !!**  
**Exclamation marks are bad too !** (yes they are)

The only time breaking this rule has worked was a when hardcore programmer who learned the Postscript language that Windows uses to talk directly to printers developed a program that printed his CV as concentric spirals of text in varying size. Viewed on screen it would slowly spin. Yes, Dominic hired him...

If you're not prepared to spend at least a month learning reverse Polish notation, use a standard template. (Stick to two main font families, a sanserif, such as Arial, for large headings and serif font, such as Times, for main body text.)

### PDF

Make a PDF if possible. These have a more professional feel than Word documents and they do not have virus problems (yet) and they retain original fonts and layout. They will usually prevent people messing with your CV, provided you set the security options. Whatever software you use, print it out to make sure that what you see is really what you get. Perhaps view on and print from another PC to double check. A free 30-day PDF maker is available from Adobe.com and there are numerous utilities available at sites like Download.com. This is also important when dealing with some Headhunters. Some like to "improve" your CV and this can be good, especially if a professional makes it better. But some HHs have a rather impressionistic view of quant finance and also may be tempted to "add" skills, as well as "correct" spelling. This does not always end well; sometimes the "improver" gets a bit carried away and it does really happen that "PDE" can accidentally get "fixed" to so that you apparently know a lot about "PDF". Funny, yes. Good for your job prospects? No.

PDFs can be locked like this one, if you can't work that out, let us know and we'll help.

### Document name

Give your document a name that will be meaningful to the recruiter. Call it YourNameHere.pdf but not CV.pdf or worse still "temp". No, we don't know why people do this. Making it easier not to be lost is in the spirit of making it easier for the recruiter. It's not nice to have a large number of files with the same name and it's actually quite easy to get your CV written over by the CV someone else who also called it "CV". Yes, this happens as well and if your CV gets lost you don't get the job with 100% certainty. At a conference recently Dominic was told by one senior manager at a top tier bank that just one large headhunter alone sent him 4 CVs *per day*. Easy to get lost in that.

### Dates

Make sure your dates "join up" as much as possible. Some people in the recruitment process worry about gaps. Do make sure that they make sense, you are supposed to be good at numbers remember? Of course sometimes they need a little explanation and at P&D we really like to know about when you were studying and working in the same period, or as with one candidate working on a national TV show. Managers often ask and not only do we not look good if we can't come up with answer, nor do you.

### Be honest

If you claim skills in some area, it's a good bet that you will be asked questions about it. The CV should be a fair and positive statement of what you have to offer. No one expects you to share your history of skin diseases, but you're going to be expected to back the talk with action and as we say earlier it can help push them into asking questions on your best subjects.

Even honesty is not quite enough. You may say you have a "basic" level of skill, but some managers just see the buzzword, and fire hard questions anyway. The only thing to do is make sure you don't let it rattle you.

### Show that you can do things

By this point in your life you've soaked up a lot of information and acquired skills, which is of course, necessary, but it is not sufficient. A big question in the inquisitor's mind is whether you can translate this into real actions that are finished, complete and correct. One can pass most exams by getting answers wrong, but by showing good working and an understanding of the principles. However, banks aren't really all that happy if you lose a pile of money by getting "nearly" the right answer, where you put a minus where it should have been a plus, the sort of mistake, we've all made on a paper. They like to see projects where you've started, worked to a goal and completed without having to have your hand held. This is a big reason why they like PhDs since it's a powerful argument that you can complete things. However, if you're going for a PhD level job, you still have to beat others who have reached that level.

Although it is their job, managers often don't really want to manage people much if they can avoid it, and will select (and pay for) people who need to be told what to do less often. Of course they tend to like people who also do what they are told.

Projects completed are good and you should be prepared to answer questions on them. The people who interview you will often have your sort of academic background, so these questions may be deep. You may have changed direction in your career and you should be prepared to answer why you made any given choice. It is important to be able to show that you didn't just "give up" on an area when it got tough.

### Interests and hobbies

Several of the people you meet will want to understand what sort of personality you have, or perhaps even whether you actually have one. Don't try to be someone you aren't and certainly it's very hard to guess what exactly they want anyway, just try to be a good version of yourself.

In finance you spend more of your waking hours with your colleagues than the person you marry, so it is good to present yourself as interesting as well as smart. They all want to feel you can work with others, so the cliché of "reading, walking and listening to music," don't really cut it.

Certainly you shouldn't fake an interest in something, but do try to find something with which you can speak with a little passion. One candidate had acquired a formal qualification in stage combat. Although it's relatively rare these days for quants to engage in single combat on the trading floor with swords, it's the sort of thing that catches someone's eyes and can make a crucial difference. It also gives the non-specialist people who you will meet something they can talk to you about. This may sound trivial and sometimes it makes no difference, but even a small difference can be important. If you think that it might look out of place, then again all you have to do is ask.

### Last job first

In your CV your most recent/current employment should stand out and be relevant to the job for which you are applying. Someone reading your CV may never get beyond this one piece of information. Make sure your dates are correct. As part of the pre-employment screen at most banks, they check your past employment and people have had offers withdrawn because of mistakes on this.

### Summer jobs

Most of us did summer jobs whilst studying and occasionally they are useful beyond the welcome input of cash. However if they don't serve to indicate something useful about your abilities, they should not take up much space, if any at all.

### Paul & Dominic

When applying to P&D, we also like to see a simple list of the various skills you have acquired, together with some estimate of how good you are. If you're new to QF then it won't be obvious which are most important, that's our job, so include as many as possible. They are for our own internal use only, so don't worry about formatting.

### Multiple CVs

Finally, there is no reason why you should have only *one* CV. Presumably your entire life doesn't fit on two pages and it can be hard to work out what to include. Thus the optimum may be to produce a variety of CVs, each emphasizing different aspects of your experience and education. You may take this as an exercise to work out the optimal number of variants and you will quickly find out that it is not one. This is made more acute by the fact that failed CVs get little if any feedback. Think of it as shooting in the dark. If you don't hear a scream when you fire in one direction, you aim somewhere else. This is a useful tactic when you're not sure whether some skill or experience is good or bad. For instance you may want to avoid jobs with too much programming, but it's hard to get a job with no programming skills. Thus you can vary the amount of this you put on your CV.

### Finding banks

In this document, we use the term "bank" for the firm you want to work for. It is course the case that quants work for many types of outfit, including brokers, the government, hedge funds, insurers, thrifts, consultancies, building societies and of course in the case of P&D, for a headhunting firm. The wilmott.com website mentions any number of firms and before you approach anyone it's good to do a few searches so that you know the nature of the target. If you're still linked with your college then it has many resources to help you. Most have a careers office with directories of banks and they will have some contacts with banks in that country. The library will have directories and of course there is Google and Yahoo for getting a list of targets.

All large firms have entry level programmes of some form and you can relatively easily find a good number to apply for. At this stage numbers are important, since the ratio of new entrants to the market to jobs is quite high.

### Direct Applications vs Headhunters

Of course, being headhunters we despise direct applications since they take away money from feeding our children. The optimum course is a mix of direct and brokered approaches to banks. There are a lot of CVs sent to a bank and typically each one does not receive that much attention, so it is useful having someone to sell you and prod the manager into making the effort to interview you. This is not trivial. On the day we wrote this, one of our candidates was being interviewed by a top 5 bank 7 months after applying. Apart from finding the right hiring manager (who has changed in this period), gently bugging him, their application has twice been thrown away by their email system. That happens more than you might think. Your Gmail account has a couple of gigabytes (please tell me you're not on AOL), but the average corporate mailbox has a limit of 100 megabytes and often this is policed by random deletions of mail. Yes, really.

## Interviews

When you submit your CV, the a priori probability of getting that particular job averages about 2 to 5%. If you've got to interview this has jumped all the way to 10-15%. That is if you haven't ended up with a carpet bombing headhunter.

### Be prepared

Before you go for the interview, find out the names of the people you are seeing and do a Google on their name, as well as the bank/business unit you are joining. Try to avoid the error made by one candidate who could not understand why the interviewer was so interested in one part of her thesis. The candidate had quoted papers by the interviewer, but somehow managed to not connect the interviewer's name with the paper. They were quite shocked when at last the connection was made for them. This was funny at the time, but they didn't get the job. This is less rare than you might think. Many quants have written papers, especially those who may interview you and your thesis will reference any number of other papers, pushing the probability up. This can work for you as well. If you find some intersection, then there is a rather higher probability that you will be asked on this aspect of your work. Make sure you've read up on that area and thought about it before interview.

### Show some market insight

This doesn't mean you have to know the ticker symbols of all SP500 stocks, but it does mean you should be able to comment on the reliability of common models, what are their main pitfalls and how the quant and the trader might communicate about this. If you can quantify some practical phenomenon that is rarely discussed in academic literature then you will impress. (Tip: Because banks are often delta hedging, everything usually boils down to gamma and/or volatility.)

A standard form of interview question is to ask about the assumptions of a model and whether they are realistic. You should start with the set of assumptions/defects in the classical Black model and work your way up from there.

It is also worth reading The Economist for at least a month before interview. Some interviewers are keen to see if you have awareness of the world in general. The Economist may disturb some people since it covers other countries and has no astrology column and relatively little coverage of golf. For instance you should reach the stage where you understand the relationship between the current price of oil in nominal terms, as opposed to its high in real terms. If you have a physics or maths background, or are generally lacking in basic knowledge of Economics, you should also try to reach the stage where you can guess what happens to the supply of oil when the price goes up. A surprisingly large number of market effects are best explained not by stochastics but by bog standard supply and demand, for instance the non-intuitive way yield curves behave in long maturity government debt. If you are completely stumped in trying to explain something, a good straw to grasp is this very basic concept.

## Brainteasers

There are several different types of brainteasers you might get asked, all designed to test how your mind works under pressure and to try and gauge how smart you are, rather than how much you have learned. This is an area where you should spend a significant amount of your preparation time. After >20 years of education, your ability at mathematics is not going to change all that much in the next few weeks and to an extent the same applies to finance knowledge.

At Paul & Dominic, we have been studying why people *don't* get a given job, to see how we can help increase the chances of getting our people in and match them better to the roles on offer. One of the largest variable factors is brainteasers, puzzles, etc. Our estimate is that with diligent study and assuming that you are basically quite bright, you can reduce by around 50% the chance of losing out this way and overall there is no single factor that you can change so quickly that has such a big effect. Some people are effectively weeded out at the brainteaser stage. Thus for the job seeker, it's quite likely that the most valuable resource on wilmott.com is the Brainteasers section of the forums and they fall into the following broad categories.

### Straightforward calculation

Example: How many trailing zeroes are there in 100 factorial?

### Lateral thinking

Example: Several co-workers would like to know their average salary. How can they calculate it, without disclosing their own salaries?

### Open to discussion

Example: What's the probability that a quadratic function has two real roots?

### Off the wall

Examples:

How many gas stations in the USA?

How many manhole covers are there within the M25?

Why are manhole covers round?

Why are manhole covers being stolen?

### General Probability and Combinatorics

Examples: You toss a coin 20 times, what is the probability that you get *exactly* 10 heads?

There are 36 people in a room, what is the probability that at least 2 of them share a birthday?

### Conditional Probability

Example:

Monty Hall problem. These seem to be the most common type and a lot of quant finance is probability so demonstrating a grasp will do you a lot of good. Also tree-type problems where coins are tossed.

## Numbers

It's worth having a few numbers at your fingertips for the "manhole covers." One manager recently told me in rather despairing tones of the stream of candidates who didn't have even a rough approximation to the population of the country they were born and educated in. Several put the population of Britain between 3 and 5 million (it's around 60 million) Actually it's a bit more, a good trick when "estimating" is to pick numbers with which it is easy to do mental arithmetic. Sure you can multiply by 60.21, but why expose yourself to silly arithmetic errors?

It's also worth revising some basic probability and set theory if your recent study hasn't covered them. Converging series can make apparently very long-winded calculations deliver quick results. It's actually quite rare for them to really want you to add up the numbers between one and a thousand, but having the formula at your fingertips is good. Indeed that sort of inductive proof is good practice for brainteasers in general. Quants tend to have greater depth in applied maths than pure and that can be a weakness when good brain teasers come more often from pure.

In many types of question, they want to hear your train of thought and have simply no interest in the actual answer. Thus you need to share your thoughts about how you get to each stage. You also should "sanity check" your answers at each step and make sure they're aware you're doing it. This is a soft skill that's very important in financial markets where the money numbers you are manipulating are rather larger than your credit card bill.

Given the free form nature of the questions, it is very easy to slip into a set of numbers where you end up with silly numbers for a given quantity. That's perfectly acceptable, *provided* that you catch yourself, indeed you may impress more this way. Thus it's worth trying to estimate the rough bounds for a numeric answer. For instance it's not likely than more than 1% of the population work in gas stations or are engaged in stealing or replacing manhole covers.

Work through the Brainteaser Forum on wilmott.com. You can practice for IQ tests and the more you do, the better your score. Brainteasers are no different. And you'd be surprised how often the same questions crop up. We have spoken to job seekers who have been asked the same question at more than one bank.

### Be confident

Relax, the hardest step is already past. Most applications are rejected without the candidate being seen by anyone. Merely be getting through the front door, your probability of getting this job has gone up by a factor of three or four. Almost no one at banks actually enjoys interviewing people, some even see it as a form of punishment. That means they only interview you if there's a good chance they will want to hire you. Most people who are considered for any job never even get a first interview. You don't need to be arrogant about this, just know that merely by getting an interview you've beaten a good number of your peers and that your probability of getting the job is on the way up.

### Be punctual

This shouldn't need saying. If you can't be on time for your interview how can they expect you to put in 12-hour days? If you are going to be late (and assuming it was unavoidable) telephone ahead with an accurate ETA. The best strategy is to schedule having a coffee before the interview, a little caffeine and sugar may well help and this is a useful time buffer. Probably the worst bit about being late is not what it does to the interviewer, but what it does to you. The idea is to present yourself as cool, smart and in control. If you've been stressed out dealing with transport problems you knock a few points off your performance.

Dominic once went to an interview where the headhunter had given him the address of a building the bank had left two years previously. He ended up very late. Banks also often have several buildings some distance apart make sure you are going to the right one. For instance Barclays has a large tower in Canary Wharf, London with "Barclays" written in big letters on the top. Do not go there. The Capital Markets Division is right next to the Station, but cunningly has no indication that they are inside and if you leave by the wrong station exit, it can take 10 minutes to find. No one knows how many offices UBS has in London, but fortunately they are all close to each other. Because it is a listed building Goldman Sachs main building in London has "The Express" written on it. The point here is that you should make sure that you have time to spare; so that this sort of thing is a little puzzle not something that brings you late and breathless to the interview.

Carry the phone number of the bank with you, both of the manager to apologise and reception who will be able to help you find them. Also getting there vastly too early annoys some people. Dominic was present at one very large firm where someone decided to show how keen he was by arriving 45 minutes early. This needled the very busy interviewing manager so much that as she left to collect him from reception she was heard to mutter "well, we won't be hiring him...".

Some reception areas get very busy and also seem to double as switchboard operators, so allow 10 minutes for this. It doesn't hurt to try and get hold of the names of other people you may be seeing.

### Set traps

Although some questions are set in advance, most interviewers like to also drill down based upon your answers. Thus you should try to mention things that you feel confident in answering hard questions about. This is best done subtly, by phrases like “this is quite like X, but the answer is Y,” where X is a bastion of your competence; or by saying thoughtfully “this isn’t like X at all,” if you feel you are being drawn into an area where you will sink.

### Show you can do things

We mention this in the CV section and here’s a chance to “casually” drop in things you’ve done that show you can dig in and finish the job. It’s OK to mention problems you overcame and the lessons you learned from initial difficulties. Good managers are sceptical of people who claim to glide effortlessly through life and don’t want to be there when such a person hits a rock.

Back when Dominic had a proper job, a senior manager overruled him over an interviewee who claimed to have found “no problems” when dealing with a dreadfully difficult piece of work. Not only was the person hired, but three months later had to be removed from the building when he attacked his PC with a screwdriver and his feet. Screams were heard. It wasn’t pretty. That is an extreme case (no Dominic didn’t say “I told you so”), but you do yourself more good by showing how you got through hard problems than by saying you found it all easy. However, it is generally not a good idea to blame all your problems on your previous manager, as we shall see later. If you’re new to finance then you may find it hard to find examples that are directly relevant. It is worth spending a little time trying to find good examples from your academic work especially projects.

Practical ability is therefore something that you will need to demonstrate a little more than theory. You wouldn’t have reached this point if you didn’t have a respectable record for absorbing many different concepts. So the next step is to see if you can apply what you’ve learned. When asked your motivation for moving into finance, it’s worth asking yourself if this is true for you.

### Questions for the interviewer

It is a good idea to have a question thought out in advance – it makes you look interested in the position. You have two objectives when they ask if you have questions for them.

### Getting the message across

A question can be a good way of bringing in things you want them to know, or to emphasise a point you want them to remember. You can ask the importance of your experience in MC, C++ or PDEs to the work you'd be doing. This gets the message across, either as a reminder or to bring it to their notice.

### Find out more about the job

Good questions are on the direction for the team over the next year and how your work would help them get where they want to be. It shows interest and may give a better insight into what you really will be doing. Although they are interviewing you, it is also the case that they are selling the job to you, since they want you to accept if they offer. So it's up to you to work out whether it's a good job or not.

Remember - do not ask things that you should already know, unless this is a ploy to reinforce some point you want them to remember. You should discuss the job and the bank as much as you can with your recruiting consultant ahead of the interview and consult websites and any recruitment brochures. You don't want to give the interviewer the impression that you aren't interested enough in their bank to find out about it before the interview. Interviewers often say that this is the thing that really irritates them most at interviews. The same applies to the business area. At entry level there's at least 50/50 will be asked "why do you want to be a quant in electricity futures?" With that level of probability you should spend a little time on some sort of answer. A smart manager will know that you don't have a deep understanding of the business he's spent 10 years mastering, but you should try to make a good shot at it.

Where possible it is good to preface a question with a statement about some achievement that the bank is proud of (i.e., talks about at length on their website or in recruitment materials) e.g., "I know your office won the International Finance Press Award for Being a Bank last year, but could you tell me..."

## Appearance

It is entirely possible that in your interview process that every person you meet is not wearing a suit, some may not have shaved. That doesn't make it wise for you to turn up in "smart casual." How you look is not a big deal for quants, you're being paid to think. However, some people do get remembered for the wrong reason and it can undermine your application a little. You should feel comfortable and if that means a bit of perfume or good cufflinks then that's fine, but see below...

### Neatness is good

More important than colour of cloth or design of tie, is the general impression of being in control of how you look. This means wearing it well and being ordered in your appearance. It is worth checking this before you go into the bank. Most banks have a toilet near reception you can use, since you've taken our advice and made sure you have time to spare, you may want to check yourself out in the mirror.

### Colours

Black is the new black. White is nice for shirts and for no other visible item of clothing. Shoes should be clean and preferably black for men and muted tones for women. A particular issue for women is the poor workmanship in most of their shoes. Do not attempt to walk long distances in new shoes that hurt your feet so badly they bleed (we know one person who stained the carpet with her blood). Make sure your clothes fit – badly fitting clothes do not look presentable and if your trousers are too tight you (and everyone else) will find this distracts from the matter at hand.

There are some complexions that are generally complemented by certain colours and apparently in some circles "brown" is seen as a colour for your clothing. It is not; it merely says things about you that are never said to your face.

Dark blue is good as well.

Ties are best boring, novelty is bad.

Another reason for white shirts is that they don't show sweat, some colours do this terribly and it's not the image you want to project. A good shirt doesn't crease badly in wear. (Dominic wears Thomas Pink shirts, two-fold Egyptian Poplin, though Twill can look quite good). This is of course a fine example of how you should dress if you want to look like a Headhunter in global financial markets ☺

### Jewellery

This will never help you get a job, no matter how expensive or fashionable. Thus if you have any doubt at all, don't wear it. If you're female and you have some brooch or bracelet, that's fine, but there's no upside for a man at all in bling. Cufflinks of course are fine, as long as they are not "novelty" – you have no idea as to the sense of humour your interviewer may have: he may not have one at all. Some banking people spend quite appalling amounts on their watches, so don't even try to compete.

### Perfume and aftershave

Feel free to smell nice, but make sure that it's not too strong. Some meeting rooms have poor ventilation.

### Traveling issues

One piece of feedback we got from the first edition of the Guide was smell. Public transport can be hot and sweaty and suits aren't really ideal clothing for keeping cool. For a short journey this doesn't really matter. However, if you're traveling for several hours to get to your interview, on perhaps the EuroStar combined with the London tube, you can end up with a quite noticeable whiff. This has affected the interview of more than one candidate, so it's worth doing what you can to keep cool.

### Make-up

The following is for women. If you're a male reader, you really should not be reading this paragraph and we are rather concerned that you are. Unless you really never wear make-up, a small amount is a good idea. Again, this gives the impression that you are making an effort and will possibly counter the deadening effect of all the monochrome clothing you are wearing. It should be discreet (i.e. no bright colours) and presentable rather than intending to make you look prettier. There are jobs that you can obtain by being attractive, but they are rarely fun and never intellectually rewarding. Any make-up should always be well applied – if you can't get eyeliner on straight, don't put it on and never wear nail polish if there is any chance it will chip before the interview.

### ***Ignore this section***

But ultimately this is all froth. Unless you apply some creativity to your appearance, it's unlikely to seriously hurt your application. We include this section because we see that it stresses some people and unnecessary stress does possibly does more harm. Be neat, turn up on time and you've already beaten a few percent of your competitors. Things change when you go for your second job. Often your employer will have a "smart casual" dress code, or maybe no code at all. This means that if your interview takes place at lunchtime or directly after work, you will turn up in normal working clothes, rather than a suit. This doesn't matter, even slightly, though you should make sure the HH knows this so he can set the right expectation.

## What People Get Wrong

### Why your boss is a jerk

If you're leaving your job, it's of course likely to be because you've stopped enjoying the work, or that your job doesn't offer you the opportunities you want. Money may well be a factor and as HH's we don't have a problem hearing this. Money has many problems but at least it is relatively simple as a motivation.

Sometimes however we hear from a candidate that it is because his current boss is a shambling moron whose personality is an unstable mix of dishonesty and ignorance barely held together by malicious greed. His management style draws upon both forms of Marxism, both Groucho and Karl. He can recite "The Art of War" from memory and he frequently quotes from it at meetings (in the original Chinese of course). You feel you have to leave now or you and he will settle your disputes with knives. The IT at your department looks like it's run by EDS, the management are in league with Al Qaeda, compliance has been infiltrated by Accenture and Jack Bauer has told you that the back office wants you dead. Today you found a live rat in your coffee.

### Why he isn't

At P&D we like to hear the truth about how you see your current role and how it's developing and an honest summary of your reasons for leaving. That means it's fine to share with us your views on the personalities involved and how things could be better. This sort of information helps us fit you to a new job rather more accurately. However, when you go forward to a bank, part of your value is your experience at this firm, indeed the branding you get from working at your current firm may have been a major factor in landing the interview.

Some managers like to see people who come from firms that they know and respect. That's not always the case of course. Dominic once hired a network manager away from a major outsourcing firm on the grounds that anyone who could achieve anything there must be remarkable. At the very least they usually won't hold your current firm against you. So if you knock your current firm too much, you are to an extent, knocking yourself.

You may not even have a reason for leaving, and that is perfectly fine with us. What we care about is interest in the new job, or at least an open mind to other career options. That applies at interview, not just a chat over coffee with us. Someone who is happy where they are, but sounds positive about a new job presents themselves far more successfully.

### Quantitative Finance is like sex because...

Jobs are not unlike relationships with the opposite sex and it's stupid to start a first date by enumerating at great length the defects and personal failings of your ex. They may indeed have slept with your best friend, or applied on your behalf for a job at EDS, but leave that baggage behind. We have experimental data to support this.

It is much better to talk of the positive reasons for leaving and your enthusiasm for the opportunity that you are now looking at. To get a good job, you need to be able to show your good work in some environment. You should think through the positive things about your current job, even if that's hard. This is always good idea, even if your current boss is not a terrorist, just so that you can think through in which ways (if any) that this new job matches what you really want. You don't get to change jobs all that often, so you want to make the right decision. This obviously goes beyond money, though that doesn't hurt. You should try to see what parts of the new job you would particularly enjoy doing. You may well be asked why you want this job and although it's a soft question, people often manage to get it wrong.

Another reason for not sounding too negative about your current job is that if you seem too eager to jump ship, it undermines your negotiating position.

### Zeroth law of holes

When you find yourself in a hole, stop digging. You will be asked questions for which you can't think of any answer at all. Some interviewers make the questions harder until that point is reached. The trick is to cut your losses. With any luck they will just move on, unless it's a critical topic. Of course if it's critical then it's game over anyway. What you must avoid is wasting time wandering like the lost spirit of ignorance over a vast formless expanse of your incompetence. A good response is to look them in the eye after a little thought, then simply say "don't know, sorry."

The exception to this are the "all the tea in China" questions where you are asked to estimate some quantity like the number of bull testicles consumed by McDonald's customers per year. You aren't expected to know the answer to these, indeed knowing it would seem rather strange. They want to see how well you can estimate an unknown quantity and how you think.

But the biggest hole catches people who get very nervous when things go wrong. This is about the most negative personality defect you might have in a bank. When you realise you've said something tragically dumb, stop. Then say something like "let me think about that for a second," and correct yourself. Make the pause work for you. Think the answer through and show that you are capable of recovering. Remember that no one can talk about things at the edge of their competence for five hours without saying something silly. You don't have to be defect free, but self knowledge and recovery from a slip will score you vital points.

### Sleep regularly, sleep often

Probably the most common error we've seen is not getting enough sleep the night before. As we said earlier, the difference between you and your competitors is tiny and losing a small percentage of your thinking ability through being tired has a non linear effect on your probability of getting a job. Hours in a bank can be quite hard, so it's really not a good idea to mention feeling tired as an excuse for a poor answer. Not only will they not be impressed, but if you get drawn into a conversation about how it degrades your performance it won't end well.

### Make eye contact

You need to make sure you look at your interrogators, they can smell fear. No need to stare at them, just remind yourself to look at them when they or you are speaking.

### Apply for the right job

You may feel you are unique individual and an obvious match for the job. Sadly, that turns out not to be the case. If you are applying for a job called “Henchman to Assistant Quant’s Minion - P&D0701067,” then do try to include that in your application, prominently. If you don’t include this, then you are critically dependant upon whoever opens your application guessing what job is best for you. If any. It’s entirely reasonable to apply for a job where you don’t quite match exactly what they are asking for. Many job specifications are a wish list rather than a set of critical skills. It is possible to get hired because strength in one area overcomes weakness in another. But make sure that this is a decision, not sloppiness. It doesn’t come across well when candidates who are selling themselves on being smart, have failed to understand the one or two paragraphs of the advertisement.

### Spam

When a web site asks, “shall I send this stuff to your friends?” do not say yes. Dominic gets a stream of emails via one candidate asking him to join some sort of SMS dating agency. The candidate name is on each one. This does not make you friends.

### Barbarians

The word barbarian comes from the ancient Greeks who took anyone who didn’t speak Greek as making “bar bub bar” noises, like a drunk Homer Simpson, not Barbarian as in the icy commanding tones of Governor Schwarzenegger. Although Dr Simpson has enjoyed careers as an astronaut, rock star and nuclear engineer, few of us would hire him as a quant. It’s important to get the right balance between gushing at people so fast that they have trouble following you, or being too quiet. You should try to practise looking at the reaction of people talking to you and if the interviewer is clearly trying to move on, you usually should let them. If you think of the conversation style used when first meeting someone you find attractive, you won’t go far wrong. (Just remember it’s a first date)

It is also the case that no one wants to discriminate against those who aren’t English speakers. This is good, but means that if you aren’t understood they may just skip over what you say, rather than pass comment on your accent. This is especially true when having a telephone interview where you will not get visual feedback and the sound quality is degraded.

### Read your CV

Make sure that your CV is correct. A surprisingly large number have dates that are clearly wrong, or that by accident give the wrong impression. These worry interviewers a lot and if your dates don’t match, this can lose you an offer when they do the basic background check on all employees. Also read it to work out which questions it might provoke them to ask, “why did you pick X?”, “I see you’ve done a lot of Y, here’s a hard question about it.”

### Mobile phone interviews

We're old people (>35) and thus sometimes use quaint 'phone technology which involves long copper wires physically connecting us to a huge ancient UNIX computer miles away (yes, we still use miles). A typical quant has done enough physics to know that you can actually talk down metal wires rather than a 1 mm thick cell phone that has more processing capacity than its owner. Sadly, the quality of cell phone speech is hideously degraded and on many systems you can't both talk at the same time. This is occasionally awkward when both speakers have the same first language, but if both have English as second language neither comes out of the conversation impressed with the other. The worst case is where the interviewers are sharing a speaker phone to you on a mobile, which is better imagined than experienced.

Do not attempt to do a phone interview on a cell phone.

### Don't send a blue CV

Just don't, OK?

Yes, it happens. CVs should be black and white. This is the default in all word processors for a good reason. So far we have received three in this form.

### Focus

Forging a rapport with the interviewer is a good thing, but some interviews drift off topic as the people involved chat. However, there is a time budget for each interview and most managers have specific objectives in checking your ability. If they don't get covered it can hurt your progress to the next stage. Although it is the interviewer's responsibility to get things done, it's *your* problem if he doesn't. This is where the politeness we mention elsewhere is important. When you feel that time is moving against you, ask to make sure that everything they need to know is covered. This is a good thing to say in any case.

### Asking questions

Actually there *are* stupid questions. Bad questions are ones which embarrass the interviewer, or force them into corners. That's *their* job. Do not try to score points off the interviewer, either you fail and look silly, or worse still, you succeed. It's a bad idea to bring up any screw-ups that the bank has been involved in, or where the manager has to admit that he hasn't read your CV.

### Buzzwords

Your interrogator will often come from a similar background to you, but even within maths and physics there are many specialisations that are mutually incomprehensible. You're just emerging from a discipline where you think in terms of these names and equations and it's easy to emit a stream of noises that your interviewer can barely understand. It's actually worse if they are from a similar background, since they may feel embarrassed to ask what you actually mean. Use of obscure technical terms may be good for impressing your buddies at college, it's not a great way of getting a job. You can lose points here. But it is generally polite to enquire about the background of your audience when asked to explain some part of your work. This both shows consideration and prevents you making this error.

### Not Knowing what you did at university

Please read your CV at least a week before you turn up for interview. It is very likely they will ask you questions about your work experience or some skill you gained at college. It looks very bad when you say on your CV that you spent three years mastering a subject, but cannot remember any details of it. A quick brush up reduces the chances of a sudden memory lapse that loses you the option of a good job.

### Be polite

Your mother told you this would be important one day, this is the day. “Please,” “thank you,” and actually looking as if you are listening are good things. Fidgeting, playing with your tie, or looking like you’d rather be somewhere else isn’t polite. Standing when people come into the room is good, preferably holding out your hand to be shaken. Occasionally you will find it appropriate to disagree, this is good since it can show that you’re thinking about what they’re saying, but get in the habit of using phrases like “I’m not sure if that’s the case, perhaps it is...” You can’t just wake up one day and be polite on a whim. (Hint: “Pretty Woman” is fiction, we know this for a fact.) Without practice, it may even come over as sarcasm. In some languages “please” and “thank you” are implied in the context of the sentence and that habit can spill over into English. Break that habit, break it now.

Practise sounding positive about things.

You *can* become better at presenting yourself as someone who’s easy to work with. This is so important because your team will spend more waking hours together than most married couples and senior people want to know you will “fit in.” Like much of this whole process it’s a game. No one really cares if you have a deep respect for your fellow man, but if you can emulate it well under pressure it’s a difference that makes no difference.

### Be true to yourself

You are selling yourself, so obviously you will be putting a positive spin on things. However, this is a career, not a job. If you feel the job may really not be what you want, then it’s important that you think that through. If in the interview you hear something that sounds bad, ask about it. This does not have to be confrontational; you can use phrases like “how does that work out in practice?” and “what sort of flexibility is there to choose the work?” when told you’re going to be counting buttons for the first six months.

### Do not sound as if you work for Accenture

Even if you do work for Accenture or Arthur Anderson, you don't want to sound like you do. Avoid the sort of management consultant pseudospeak that resembles Dilbert cartoons. A common type of interview question is of the form: "you find that something has gone terribly wrong, what would you do about it." An Accenture style answer is: "I would see it as a challenge that would allow me to work as a good team player, as part of the global strategy, being careful to solicit input from business stakeholders"; or perhaps you might respond "I will grasp the opportunity to show excellent leadership in integrity" which is interview suicide. Or to quote one person, "I love pressure, that's why I want to work for a bank" Sounds good, but at some level, also slightly worrying.

This warning may sound quite silly, but there is a growing trend for some universities to have formal coaching in interview technique. In theory this should be very useful. In theory. In practice it comes across as rather scary. It frustrates interviewers a lot to be faced with an obviously bright candidate who parrots clichés that some consultant has fed into him. We say at the beginning that you need to stand out and given that the people you are competing with may well include people from your institution, it does you very little good. By all means listen to these people, but take it with a pinch of salt. When you know little about the process, it's easy to give too much weight to the few things you get told. We also ought to include something that nearly contradicts everything else we say on this subject. Don't be too self conscious. Many of us have had recordings made of presentations, on subjects we're supposed to be experts in and giving a professional lecture. Which we do, usually.

Except of course no one can talk for hours without sentences that make no sense or lack verbs, or saying something that's so flatly wrong, you'd swear you never said it. Don't sweat about this.

### Interview overlap

It is tempting to schedule lots of interviews as close together as possible, because travel does eat into your budget. You should be very conservative about the amount of time you allow for each interview. It's not easy to get a manager to speed up his process because you want to get across town to talk to one of his competitors. The worry about time, just like lateness, can reduce your effectiveness, so make sure this doesn't come up.

### Odd Questions

You will be asked some rather strange questions, not just brainteasers. They include “can you work in a team?”, “do you want to work in a bank?”, “what motivates you?”, “what sort of team do you want to work in?” and variants on “you don’t know what we do precisely, what difference is there between this kind of work and some other work you know nothing about?” They are serious questions and although some of them like “do you want to work here?” have obvious answers, you do best by thinking about them, preferably in advance. You should be able to articulate *something* that makes you want to work for this business in this bank. You should have views on teams. For instance, now that you aren’t competing with me for jobs I can share with you that when asked about the ideal team size for me, I have said “for me, what is important is the quality of the team, rather than its size”. Which has the virtues of not cutting yourself off from whatever size of team you might join (by not actually meaning anything) and also sounding positive and upbeat.

A bad answer is “I like small teams because you don’t really know what strangers are thinking.” Even the largest banks are typically a large number of smallish, 5-20 person groups, that’s basically because we evolved to work best that way.

## Spotting Bad Jobs

You will often hear and read various bits of gossip about firms, but the problem is that the quality of this information is low, not only wrong, but often imprecise. It's entirely possible the fixed-income division at a bank to be doing very badly at a time when equity derivatives are making a big pile of cash, indeed there are known correlations based upon the markets that cause such effects. In many ways an investment bank is like a franchise of many businesses sharing a common infrastructure. Thus you will see areas that are great and successful not far from those that are not doing well at all. Your interest needs to focus on the division and the people who you will be working with and who you're working for.

The press carries little if anything of use to the job seeker in terms of trying to work out the real nature of the bank you are seeing. Obviously if there are lay offs, then it's a bad sign, but there is simply not the level of detail you need to make a good decision. There's no magic formula for spotting a pothole in your career, but there are a set of things that you should think about. High staff turnover is a bad sign of course, but if you ask this directly it may offend them and you may not get an entirely useful answer, other than "pretty average." It is a good idea to ask how long a given person has been with the team. This makes for polite conversation and you will get some idea how people's work turns out in practice, as opposed to the ideal that they tell you about.

As a very rough guide the politeness we saw earlier goes two ways. If the bank is stupidly inflexible over interview times, or you note a lack of buy-in from their attitude, these are bad signs. Of course if you're at entry level, you may be stuck in a rigid process as they trawl through what they may feel is an endless stream of identical candidates, so you have to exercise a bit of judgment. Do not forget that interviews are a two way process, they want to hire good people just like you want to get a good job. This means they are trying to sell to you and they are often very sharp people, with strong motivations, so bear this in mind when they are being nice to you. We have noted a reasonable correlation between the quality of the job and being offered coffee or water at interview.

## Who Will Interview You

You will be interviewed by several people for the one job. They will have different levels of seniority and different areas of specialization. It comes as a surprise to some people that firms such as Goldman Sachs want you to meet anything from five to 12 managers and members of your new team.

### Quant prejudices

There are many types of quant and we don't mean that they work in different product areas. Very often there can be a great deal of technology transfer from one product area to another. For example, the quant skills needed for credit and for interest rates have a wide overlap. No, we mean that quants come from different mathematical backgrounds and it is this rather than product area that will dictate the nature of a technical interview. Quants come in two varieties: the pure mathematician and the applied mathematician.

### The pure mathematician quant

This quant will have studied finance as a branch of probability theory, often quite abstract probability theory. Their degree will probably be in either finance or mathematics from a probability theory department. In their interview they will talk about martingales and change of measure, Girsanov and numeraire. Ninety-nine times out of a hundred the punchline of the probabilistic approach is the simple concept that the value of a financial contract, such as an option, no matter how complex is the expected present value of all cashflows. The expectation comes in because cashflows will vary depending on how the underlying instrument behaves and the present value appears because cashflows will be in the future and we are valuing the option today. The catch in this is that the expectation must be with respect to the risk-neutral random walk of all underlying random variables, not the real random walk.

Many problems in finance can be addressed by either the pure or the applied mathematician. However, because many interest rate models are constructed from a simulation point of view they are easier to deal with by the probabilistic approach. These models are known as the Heath, Jarrow & Morton (HJM) and Brace, Gatarek & Musiela (BGM) models. When it comes to number crunching and writing code, which is invariably what you will be doing, you will find yourself writing a lot of Monte Carlo simulation code. At a basic level, Monte Carlo code is easy to write. There are really just the two problems with it, making it fast (including finding the Greeks) and using it for contracts with early exercise.

### Key areas to brush up on

You ought to be able to understand and be able to discuss knowledgeably the following.

- Risk neutral versus real
- Change of numeraire
- Martingales
- Monte Carlo methods
- Techniques for speeding up Monte Carlo
- Monte Carlo methods for contracts with early exercise

The last two are popular areas of research, so have a few recent articles at your fingertips.

### The applied mathematician quant

The applied mathematician may have studied anything but finance. They will have degrees in physics, electrical engineering, chemistry and applied mathematics such as fluid mechanics. They will talk about calculus and partial differential equations. To applied mathematicians the problem of pricing a contract is about finding a differential equation which must then be crunched numerically. The differential equation will almost certainly be of parabolic type, also known as the heat or diffusion equation. This equation also has the same interpretation as giving the expectation of the present values of cashflows but this is seldom mentioned.

Applied mathematicians can't easily write certain interest rate models in the partial differential equation framework. However, they have other counter-balancing advantages over the probabilist. Using the tools of calculus they can derive models with fewer assumptions than the probabilists, they can incorporate transaction costs, optimality, nonlinearity and other fun stuff into their models. Number crunching to the applied mathematician can mean either Monte Carlo again, or finite difference methods. Finite-difference methods are sophisticated versions of the binomial method. No, strike that, it would be better to say that the binomial method is a prehistoric version of a finite-difference method.

#### *Key areas to brush up on*

- Diffusion equations generally
- Finite difference methods
- Finite difference methods in several dimensions
- The different types of finite-difference method: Explicit, implicit, etc.

You ought to have coded up some of these in C++ or at least VB or Matlab, otherwise you won't sound at all convincing in the interview.

#### Final trick

Often you will know the name of the person interviewing you. If you do then a simple search on Google or wilmott.com may give you information about the style of the person, their interests, perhaps even weaknesses in their own knowledge.

## HR Interview

Typically the HR interview is the last one before they offer you the job and after everyone else has signed off that they want you. Although it is not very common for candidates to fall down at this point, you really don't want to fall down at the last fence. HR is typically the only person involved in the hiring process with any real formal training in staff selection. Thus although they are not in a position to work out your maths or programming skills they are still responsible for trying to make sure that the bank is not hiring a dud. From the forums we get the impression that many people see HR interviews as a complete waste of time, many are. They are filters and sanity checks and in theory they shouldn't be necessary.

Except when they catch a dud that everyone else has missed.

They also are usually the people who understand the bureaucracy best, so gather together all you issues about interview expenses, start dates and when precisely you will get your first pay cheque for this.

## Audit

Many HRs see their role in these interviews to be catching these duds and thus although the questions they ask may be extravagantly banal, they are in fact checking that you are what you say you are. Since they have so little objective data to work on, they seize upon any perceived defects and give them a good hard shake. Back when he had a real job bossing people around, Dominic once interviewed someone who not only could not remember why they had chosen particular options on their degree course; they actually struggled to remember half of their names.

They didn't get the job.

HRs often pick up on errors in your CVs like mismatched dates and are trained not to like gaps at all. If the dates do not join up, be prepared to explain why. Part of the background check that most banks perform involves checks on employment dates. Some people's dates are rather confusing, for instance you may have studied at two places during the same period. That's fine, but worth telling P&D about it so that we can set the right expectation. The short version is that you can get away with a lot more that you state up front than if you are found out. HR will ask about how you made various choices in your life. Let's be honest here, we all have "choices" that were in reality some combination of bad judgment, ignorance, showing off and improvements to the chances of meeting people of a compatible sex. They know this as well, but they are also checking that you are capable of expressing yourself, as well as trying to guess how you make important decisions.

## Examples

A common theme in the way many people in HR approach the intangible issues is the notion of finding examples of the trait in question through your experience. Thus when you are asked whether you are happy working in teams, the wrong answer is "yes" (although it is typically better than "no"). Most often they are looking for examples of when you worked well in a team and what you gained from it, or whether you're not really that good at teamwork. There are a lot of questions on this theme and yes they do include "why do you want to work for us?" People sometimes get that wrong. Yes, really.

And then we hid the drugs under our mother's bed...

Even major governments find it hard to work out whether people they take on should be trusted; and that's with quite intrusive checks on your life and people you are associated with. Thus you should feel some sympathy for the HR who has the job of working out whether you should be trusted with millions based upon a ten minute segment of an interview. But that sympathy should be tempered with your resolution not to dig a hole for yourself. As above they may well ask for some example where you were found yourself having to make a difficult ethical choice, or how you dealt with a situation where some wrongdoing happened around you. They may ask follow up questions just to check that you are a normal law abiding citizen.

However, it may be a good idea to review your life and think of a good example. What you really do not want to happen is to find it hard to think of such a case, then remember something and start a story about the errant behaviour of your little brother and how you had to keep him out of trouble. That's fine, but think the anecdote through, because it may just end with the way you solved the problem paints you as an incompetent drugs dealer. The HR is handing you rope by letting you talk about your life. Do not tie a noose in it and stick your head through.

One candidate when asked about a test result that seemed well below their ability replied that they had been to a really good party the night before and had been in no fit state to take the exam. They didn't get the job.

### Background Checks

Nearly all banks do at least a basic background check. This includes trying to make sense of your transcripts, references from previous employers and looking for unexplained gaps in your employment history. You may gain a little personal satisfaction from your progress in life, when your ex-boss at some grim joint you worked one summer finds out that a really big bank is hiring you for such an important position that they check out your past.

These checks include a credit check. There are several reasons for this. The first is that the bank may simply not be allowed to hire people who are bankrupt, or have certain types of court judgment against them. It also serves as an extra confirmation that you are who you say you are and that your life bears some resemblance to the one on your CV.

The final reason is that it's cheap. For £10 to 30 one can get more raw information about a person than a £300 per day private detective can get in a few weeks.

At this point a certain number of you will be worrying that the rather stochastic view you took to paying your credit card is going to come back to bite you.

Not yet.

As it happens, HRs know about student finances, most of them are graduates and many have a Master's degree and thus have a relatively relaxed filter on low level student cashflow problems. So a few misplaced bills rarely disturb them very much. That is unless the amounts are so large that they imply either substance abuse or an unacceptably flagrant contempt for money. Credit checks will of course flag up potential fraud and it should come as no shock to you that banks really don't like dishonesty at all.

## The Different Types of Mathematics Seen in Finance

The real-world subject of quantitative finance uses tools from many branches of mathematics. And financial modeling can be approached in a variety of different ways. For some strange reason the advocates of different branches of mathematics get quite emotional when discussing the merits and demerits of their methodologies and those of their ‘opponents.’ Is this a territorial thing, what are the pros and cons of martingales and differential equations, what is all this fuss and will it end in tears before bedtime?

### Financial modeling

Here’s a list of the various common approaches to modeling and a selection of useful tools. The distinction between a ‘modeling approach’ and a ‘tool’ will start to become clear.

### Modeling approaches

- Probabilistic
- Deterministic
- Discrete: difference equations
- Continuous: differential equations

### Useful tools

- Simulations
- Approximations
- Asymptotic analysis
- Series solutions
- Discretization methods
- Green’s functions

While these are not exactly arbitrary lists, they are certainly open to some criticism or addition. Let’s first take a look at the modeling approaches.

#### *Probabilistic*

One of the main assumptions about the financial markets, at least as far as quantitative finance goes, is that asset prices are random. We tend to think of describing financial variables as following some random path, with parameters describing the growth of the asset and its degree of randomness. We effectively model the asset path via a specified rate of growth, on average and its deviation from that average. This approach to modeling has had the greatest impact over the last 30 years, leading to the explosive growth of the derivatives markets.

#### *Deterministic*

The idea behind this approach is that our model will tell us everything about the future. Given enough data and a big enough brain, we can write down some equations or an algorithm for predicting the future. Interestingly, the subject of dynamical systems and chaos falls into this category. And, as you know, chaotic systems show such sensitivity to initial conditions that predictability is in practice impossible. This is the ‘butterfly effect,’ that a butterfly flapping its wings in Brazil will ‘cause’ rainfall over Manchester. A topic popular in the early 1990s, this has not lived up to its promises in the financial world.

*Discrete/Continuous*

Whether probabilistic or deterministic the eventual model you write down can be discrete or continuous. Discrete means that asset prices and/or time can only be incremented in finite chunks, whether a dollar or a cent, a year or a day. Continuous means that no such lower increment exists. For reasons that we've never understood, the mathematics of continuous processes is often easier than that of discrete ones. But then when it comes to number crunching you have to anyway turn a continuous model into a discrete one. In discrete models we end up with difference equations. An example of this is the binomial model for asset pricing. Time progresses in finite amounts, the time step. In continuous models we end up with differential equations. The equivalent of the binomial model in discrete space is the Black-Scholes model, which has continuous asset price and continuous time. Whether binomial or Black-Scholes both of these models come from the probabilistic assumptions about the financial world.

*Simulations*

If the financial world is random then we can experiment with the future by running simulations. For example, an asset price may be represented by its average growth and its risk, so let's simulate what could happen in the future to this random asset. If we were to take such an approach we would want to run many, many simulations. There'd be little point in running just the one; we'd like to see a range of possible future scenarios. Simulations can also be used for non-probabilistic problems. Just because of the similarities between mathematical equations a model derived in a deterministic framework may have a probabilistic interpretation.

*Discretization methods*

The complement to simulation methods, there are many types of these. The best known of these are the finite-difference methods which are discretizations of continuous models such as Black-Scholes. Depending on the problem you are solving and unless it's very simple, you will probably go down the simulation or finite-difference routes for your number crunching.

*Approximations*

In modeling we aim to come up with a solution representing something meaningful and useful, such as an option price. Unless the model is really simple, we may not be able to solve it easily. This is where approximations come in. A complicated model may have approximate solutions. And these approximate solutions might be good enough for our purposes.

*Asymptotic analysis*

This is an incredibly useful technique, used in most branches of applicable mathematics, but almost unknown in finance. The idea is simple; find approximate solutions to a complicated problem by exploiting parameters or variables that are either large or small, or special in some way. For example, there are simple approximations for vanilla option values close to expiry.

*Green's functions*

This is a very special technique that only works in certain situations. The idea is that solutions to some difficult problems can be built up from solutions to special solutions of a similar problem.

## Reading List

### Background

Derman, E 2004 *My Life As A Quant*. John Wiley & Sons

<http://books.global-investor.com/books/19770.htm?ginPtrCode=10202&identifier=18932b1e1d2bc6d5a1ae69160e8da035>

Poundstone, W 2005 *Fortune's Formula*. Hill & Wang

<http://books.global-investor.com/books/22645.htm?ginPtrCode=10202&identifier=18932b1e1d2bc6d5a1ae69160e8da035>

Taleb, NN 2001 *Fooled by Randomness*. Random House

<http://books.global-investor.com/books/22645.htm?ginPtrCode=10202&identifier=18932b1e1d2bc6d5a1ae69160e8da035>

Brown A 2006 *The Poker Face of Wall Street*. John Wiley & Sons

<http://books.global-investor.com/books/23007.htm?ginPtrCode=10202&identifier=18932b1e1d2bc6d5a1ae69160e8da035>

To get a feel for the recent history of quantitative finance and the working environment for a quant see Emanuel Derman's autobiography. This is a very personal account of his own career from physicist to Wall Street quant. However, it doesn't really convey the role played by programming in a typical quant's life, since Dr Derman is far from being a typical quant.

Bill Poundstone writes about some simple money-management ideas well known to all gamblers yet under-appreciated by risk managers. To back up his case he describes the Long Term Capital Management fallout and the role played by leverage. This book will give you plenty of nuggets to drop casually into an interview to show that crucial market insight and how to relate markets and mathematics in a very pragmatic way.

You will either love or loathe Nassim Taleb's non-technical book on the part played by risk in our lives, not just finance. It is compulsory reading. But whether you love it or loathe it don't let on to your interviewer until you know their feelings towards it. Again, a lot of useful interview material, but unfortunately nothing mathematical.

## Introductory

Haug, EG 2007 *The Complete Guide to Option Pricing Formulas*. McGraw-Hill

<http://books.global-investor.com/books/66956.htm?ginPtrCode=10202&identifier=80d939a1914d743ad6d4673851085ba8>

Hull, J 2005 *Options, Futures and Other Derivative Securities*. Prentice Hall

<http://books.global-investor.com/books/9233.htm?ginPtrCode=10202&identifier=18932b1e1d2bc6d5a1ae69160e8da035>

Wilmott P 2001 Paul Wilmott Introduces Quant Finance

<http://books.global-investor.com/books/13754.htm?ginPtrCode=10202&identifier=18932b1e1d2bc6d5a1ae69160e8da035>

Espen Haug's book concentrates on presenting pragmatic results for the practitioner without going into all of the modeling details. This book finds a nice balance between theory and practice. Do you want the perfect model that is impractical because it takes too long to find an answer? No. Do you want a model that is quick but gives useless results? No. A chain is only as strong as its weakest link and this book focuses on models where all the links are similar in strength. Very practical. It is now in its second and greatly expanded edition.

Paul Wilmott's book is of course famous, partly for its more practical approach to quant finance and relatively relaxed writing style, presumably if you've reached this point you already have a copy, if you don't then you should get one. According to the *Financial Times*, Paul is a "cult derivatives lecturer".

Knowing Hull is compulsory. Everyone has read it. Unfortunately that means that to some extent that knowledge will have been discounted by interviewers. The book is great for definitions of things financial and mathematical. However, if you have only read Hull you will have a strange, fragmentary understanding of quantitative finance because of the pick'n'mix nature of the contents and because there is no common theme holding the book together. There is also too much on the binomial model. Although this is great for teaching it isn't great for hardcore, practical quanting. If you think that you can get a job after merely reading Hull you are in for a big shock.

## Advanced/research level

Jaeckel, P 2002 *Monte Carlo Methods in Finance*. John Wiley & Sons

<http://books.global-investor.com/books/14474.htm?ginPtrCode=10202&identifier=18932b1e1d2bc6d5a1ae69160e8da035>

Peter Jaeckel goes into the details of Monte Carlo methods. It can be quite heavy going at times, but for interview purposes you won't need to have understood everything in this book. As long as you can show an appreciation of random number generation methods, how to speed up Monte Carlo and using Monte Carlo for pricing American options then you should be fine.

Morton, KW & Mayers, DF 1994 *Numerical Solution of Partial Differential Equations*.

Cambridge

<http://books.global-investor.com/books/21542.htm?ginPtrCode=10202&identifier=18932b1e1d2bc6d5a1ae69160e8da035>

The other main numerical methods you will need to understand are the finite-difference methods. There are books on finite differences in finance (such as Tavella & Randall) but for extra kudos you would be better off reading one of the classics such as that by Morton & Mayers. It has no reference to finance whatsoever, but explains beautifully the numerical solution of various partial differential equations.

Neftci, S 2004 *Principles of Financial Engineering*. Academic Press

<http://books.global-investor.com/books/17107.htm?ginPtrCode=10202&identifier=9984462dc967c883925321992785d117>

Salih Neftci's book explains the probabilistic side of quantitative finance modeling. Although this subject can be a bit daunting because it appears so abstract, Neftci does a fantastic job of making the topic intuitive.

Schonbucher, PJ 2003 *Credit Derivatives Pricing Models*. John Wiley & Sons

<http://books.global-investor.com/books/15886.htm?ginPtrCode=10202&identifier=18932b1e1d2bc6d5a1ae69160e8da035>

Taleb, NN 1997 *Dynamic Hedging*. John Wiley & Sons

<http://books.global-investor.com/books/3768.htm?ginPtrCode=10202&identifier=18932b1e1d2bc6d5a1ae69160e8da035>

Wilmott, P 2006 *Paul Wilmott On Quantitative Finance*, second edition. John Wiley & Sons

<http://books.global-investor.com/books/23017.htm?ginPtrCode=10202&identifier=18932b1e1d2bc6d5a1ae69160e8da035>

Philipp Schonbucher is another challenging read. Entirely on the subject of credit risk modeling, if you are able to understand (and more importantly, show that you understand) just 25% of this book then you will go far, my son.

Nassim Taleb's technical book (as opposed to his popular science book mentioned earlier) combines theory and practice very successfully. This is another book that will give you useful gems for your interview.

Paul Wilmott's three-volume opus is from the other side of the tracks from Salih Neftci, it shows how the applied mathematician thinks of quantitative finance. The book starts at the standard level of explaining Black-Scholes, moving on to discussing modern quant models as used in practice, ending up with some ideas from the cutting-edge of research. One important point about this book, which distinguishes it from others, is that it does criticize many of the models commonly used by practitioners. Again, you will find many modeling insights and *bon mots* in this book that will be useful during your interview ordeals.

## What You Must Know

The following is not an exhaustive list and is only the general broad brush strokes, but it will ensure that you don't make an idiot of yourself by having major gaps in your knowledge.

### *Products*

- Fixed income, bonds, swaps
- Equity, dividends, derivatives
- Currencies, role of foreign and domestic interest rates
- Commodities, convenience yield etc.
- Exotics, main types,
- Credit derivatives

### *Concepts*

- Risk, return and efficient frontiers
- Delta hedging
- Risk neutrality
- The no-arbitrage argument
- Market price of risk for non-traded quantities
- Calibration
- Static hedging using exchange-traded vanillas

### *Models*

- Binomial model
- Lognormal
- Jump diffusion
- Stochastic volatility
- Interest rate model (single, multi factor, HJM, BGM)
- Credit models (hazard rate, structural)
- Transition matrices
- *Numerical methods*
- Monte Carlo simulation techniques
- Binomial scheme
- Finite-difference methods
- Numerical quadrature
- Which method to use for which type of contract

## What You Must Have Coded Up

### Key areas

You must be comfortable with the four main numerical methods used for pricing derivatives:

- Binomial/trees
- Finite-difference methods
- Monte Carlo
- Numerical integration

Although the first of these (binomial and trees) are rather inefficient they still have their proponents and you should show willingness to lower yourself to this level. We know of a world class numerical analyst working in computational fluid mechanics who left his academic job for the bright lights and ended up coding the binomial model. A certain amount of pride swallowing was necessary in the short term, but his recent progress has certainly made it worthwhile.

Aim to code up as many different types of exotic contract as possible, in as many markets as possible (essentially the lognormal markets of equity, FX, etc. and fixed income and credit). When pricing an exotic such as an equity Asian option you should use both Monte Carlo and finite difference. The two methods are completely different but the exercise will give you invaluable experience and plenty to talk about in your interview.

(The next few sections are taken from *Paul Wilmott On Quantitative Finance*, second edition, 2006, John Wiley & Sons.)

### *Finite-difference methods*

Finite-difference methods are designed for finding numerical solutions of differential equations. Since we work with a mesh we find the contract value at all points in stock price-time space. In quantitative finance that differential equation is almost always of diffusion or parabolic type. The only real differences between the partial differential equations are the following:

- Number of dimensions
- Functional form of coefficients
- Boundary/final conditions
- Decision features

#### Number of dimensions

Is the contract an option on a single underlying or many? Is there any strong path dependence in the payoff? Answers to these questions will determine the number of dimensions in the problem. At the very least we will have two dimensions: stock price and time, for example. Finite difference methods cope extremely well with a smaller number of dimensions, up to four, say. Above that they get rather time consuming.

### Functional form of coefficients

The main difference between an equity option problem and a single-factor interest rate option problem is in the functional form of the drift rate and the volatility. These appear in the governing partial differential equations as coefficients. The standard model for equities is the lognormal model, but there are many more 'standard' models in fixed income. Does this matter? No, not if you are solving the equations numerically, only if you are trying to find a closed-form solution in which case the simpler the coefficients the more likely you are to find a closed-form solution.

### Boundary/final conditions

In a numerical scheme the difference between a call and a put is in the final condition. You tell the finite-difference scheme how to start. And in finite-difference schemes in finance we start, strangely, at expiration and work towards the present. Boundary conditions are where we tell the scheme about things like knock-out barriers. When we write our code we'd like it to be as general and reusable as possible. That means writing it so that it doesn't have to be changed too much in going from one contract or model to another. So we might put things like final conditions in some external function, to be changed easily.

### Decision features

Early exercise, instalment premiums, chooser features, are all examples of embedded decisions seen in exotic contracts. Coping with these numerically is quite straightforward using finite difference methods, making these numerical techniques the natural ones for such contracts. The difference between a European and an American option is about three lines of code in a finite difference program and less than a minute's work.

#### Program of study for finite-difference methods

If you are new to finite-difference methods and you really want to study them then you need a program of study.

#### **Explicit method/European calls, puts and binaries**

To get started you should learn the explicit method as applied to the Black-Scholes equation for a European option. This is very easy to program and you won't make many mistakes.

#### **Explicit method/American calls, puts and binaries**

Not much harder is the application of the explicit method to American options.

#### **Crank-Nicolson/European calls, puts and binaries**

Once you've got the explicit method under your belt you should learn the Crank-Nicolson implicit method. This is harder to program, but you will get a better accuracy.

#### **Crank-Nicolson/American calls, puts and binaries**

There's not much more effort involved in pricing American-style options than in the pricing of European-style options.

#### **Explicit method/path-dependent options**

By now you'll be quite sophisticated and its time to price a path-dependent contract. Start with an Asian option with discrete sampling and then try a continuously-sampled Asian. Finally, try your hand at lookbacks.

#### **Interest rate products**

Repeat the above program for non-path-dependent and then path-dependent interest rate products. First price caps and floors and then go on to the index amortizing rate swap.

#### **Two-factor explicit**

To get started on two-factor problems price a convertible bond using an explicit method, with both the stock and the spot interest rate being stochastic.

#### **Two-factor implicit**

The final stage is to implement the implicit two-factor method as applied to the convertible bond.

## **Monte Carlo methods**

Monte Carlo methods simulate the random behavior underlying the financial models. So, in a sense they get right to the heart of the problem. Always remember, though, that when pricing you must simulate the risk-neutral random walk(s), the value of a contract is then the expected present value of all cashflows. When implementing a Monte Carlo method look out for the following:

- Number of dimensions
- Functional form of coefficients
- Boundary/final conditions
- Decision features  
again!

A common interview question is to ask the pros and cons of MC vs FD. This should be an easy point to score.

### ***Number of dimensions***

For each random factor you will have to simulate a time series. It will obviously take longer to do this, but the time will only be proportional to number of factors, which isn't so bad. This makes Monte Carlo methods ideal for higher dimensions when the finite-difference methods start to crawl.

### ***Functional form of coefficients***

As with the finite-difference methods it doesn't matter too much what the drift and volatility functions are in practice, since you won't be looking for closed-form solutions.

### ***Boundary/final conditions***

These play a very similar role as in finite differences. The final condition is the payoff function and the boundary conditions are where we implement trigger levels etc.

### ***Decision features***

When you have a contract with embedded decisions the Monte Carlo method becomes cumbersome. This is easily the main drawback for simulation methods. When we use the Monte Carlo method we are only finding the option value at today's stock price and time. But to correctly price an American option, say, we need to know what the option value would be at every point in stock price-time space. We don't typically find this as part of the Monte Carlo solution.

### ***Improvements to basic MC***

It is worth revisiting antithetic sampling, variance reduction, importance sampling and Sobol & Quasi Monte Carlo methods. A good point to reach is where you can describe the effect on apparent Greeks by calculating prices by MC and what you can do to make this less bad. A key advantage of MC is that it is so simple to distribute the work across multiple CPUs that even Accenture consultants can do it (eventually). Thus even though some methods like finite difference methods can be more efficient, they are harder to make spread the load.

Program of study for the Monte Carlo path-simulation methods

**European calls, puts and binaries on a single equity**

Simulate a single stock path, the payoff for an option, or even a portfolio of options, calculate the expected payoff and present value to price the contract.

**Path-dependent option on a single equity**

Price a barrier, Asian, lookback etc.

**Options on many stocks**

Price a multi-asset contract by simulating correlated random walks. You'll see how time taken varies with number of dimensions.

**Interest rate derivatives, spot rate model**

This is not that much harder than equities. Just remember to present value along each realized path of rates *before* taking the expectation across all paths.

**HJM model**

Slightly more ambitious is the HJM interest rate model. Use a single factor, then two factors etc.

**BGM model**

A discrete version of HJM.

## *Numerical integration*

Occasionally one can write down the solution of an option-pricing problem in the form of a multiple integral. This is because you can interpret the option value as an expectation of a payoff and an expectation of the payoff is mathematically just the integral of the product of that payoff function and a probability density function. This is only possible in special cases. The option has to be European, the underlying stochastic differential equation must be explicitly integrable (so the lognormal random walk is perfect for this) and the payoff shouldn't usually be path dependent.

So if this is possible then pricing is easy... you have a formula. The only difficulty comes in turning this formula into a number. And that's the subject of numerical integration or quadrature. Look out for the following.

- Can you write down the value of an option as an integral?

That's it in a nutshell.

### Program of study for numerical quadrature

Here is a program of study for the numerical quadrature methods.

#### **European calls, puts and binaries on a single equity using Normal numbers:**

Very simple. You will be evaluating a single integral.

#### **European calls, puts and binaries on several underlying lognormal equities, using Normal numbers**

Very simple again. You will be evaluating a multiple integral.

#### **Arbitrary European, non-path-dependent payoff, on several underlying lognormal equities, using Normal numbers:**

You'll only have to change a single function.

#### **Arbitrary European, non-path-dependent payoff, on several underlying lognormal equities, using low-discrepancy numbers:**

Just change the source of the random numbers in the previous code.

### *Summary of Numerical Methods*

The following table summarizes when the various methods excel and where they fall flat.

<b>Subject</b>	<b>Finite difference</b>	<b>Monte Carlo</b>	<b>Quadrature</b>
Low dimensions	Good	Inefficient	Good
High dimensions	Slow	Excellent	Good
Path dependent	Depends	Excellent	Not good
Greeks	Excellent	Not good	Excellent
Portfolio	Inefficient	Very good	Very good
Decisions	Excellent	Poor	V. poor

## Programming Skills

This is central to the notion of *doing things*. You will be writing code, it will be a significant part of your work. That is the way it is. We emphasise this because some new entrants to the market have somehow got the idea that programming is something they can avoid, or worse still is somehow beneath them. Frankly that is rather like the view of physics you get in the media where no maths are involved. Yes, people do think great deep abstract thoughts, but you can no more be a quant who doesn't program than a physicist who doesn't do calculus.

This is made worse by some of the various Masters in Finance programmes which either don't teach programming at all, or fail to allocate enough time to it. Overwhelmingly the skill that employers tell us is lacking in newbies is programming. Sadly there is no quick fix. The Certificate in Quantitative Finance places a great emphasis on practical techniques, numerical methods and programming and has become something of a market standard for this reason, and now has a substantial C++ component.

The programming ability of quants varies enormously, but a large percentage of your time will be spent fighting computers, so showing aptitude is frequently a deciding factor. Most quant jobs ask for C++, with much smaller demand for Java, C# and Excel VBA. Alas, Excel VBA is regarded as "trivial" so few employers will be impressed by mastering it. This attitude is responsible for major efforts at the large banks to defuse the vast number of actively disruptive, yet critical spreadsheets that enjoy the reliability of a British train.

MatLab is common in both Academia and finance, and it does not harm to have used it, but again like Excel VBA the view amongst managers is that if you are smart enough to do real quant work you can pick up whatever MatLab you need.

Fortran is still quite popular in academia, but has only a tiny market share in banks. If you have the choice for which language to use in a project whilst studying it is worth considering C++. However you should budget in extra time to master it properly. But if you've got good skills in numerical analysis in Fortran, then you've proven you can do the work. Some managers appreciate this, although others do not. Much "C++" code in banks is really much like C, and one does see "C++" code that is written using the C subset but trying to be like Fortran.

Apart from understanding the subtleties of the language, you may need to demonstrate a general understanding of software engineering. Although efficiency is, of course, good, what matters more is that the thing actually works and in financial markets you have to show a pragmatic view of how you trade off these things. There are at least two pertinent programmers' sayings:

- Fast, Reliable, Ready Soon: Pick any two
- Easier to make correct code fast, than to make fast code correct

Academic code is light on things like error handling and checks to ensure input data is of the right range. Get in the habit of thinking of “sanity checks” for all numerical values. “Working code” is not code that happens to produce the right result when you feed in carefully chosen values in a tight range. It means functions that have been tested across a wide range of values and whose output has been compared to known good values.

A common symptom of a bug like uninitialized variables, or a stack error is for floating point numbers to contain absurd values like  $6.12122 \times 10^{302}$

Deterministic routines should *always* return the same result and Monte Carlo should have known convergence characteristics.

You should get in the habit of making your code tougher, assuming that people will actively try to break it, because that is rather close to the truth.

## C++

C++ is a topic in its own right and we'll soon be releasing an upgraded version of the C++ for interviews notes. An outline of skills required for C++ is:

- Variables
- Pointers
- Classes
- Passing by value and reference
- Templates
- STL (strings, vectors and algorithms)
- Inheritance up to the level of virtual functions
- Basic OO

This represents a lower bound, below which you should seriously consider whether to put C++ on your CV without a qualifier such as “basic knowledge.” C++ is a rich domain for questions about syntax that look like someone banged their head on the keyboard. It is better to have a good grasp of the core concepts of C++ than in a short time attempt to read up the whole language. Common interview questions are of the form “which function is called,” and “what’s wrong with this code.” Often you will be expected to describe things like virtual inheritance or template specialisation.

## Numerical algorithms

It's good to have at least a basic grasp of the basic methods for solving PDEs and other maths problems. Most QF uses a mix of Monte Carlo, trees and finite-difference methods. It's worth getting to the stage where you can sensibly say when you'd choose one method over another and their limitations and advantages. There is also some demand for Matlab and Mathematica. These are mostly used for prototyping ideas, although they are also doing live work in trading.

Similar issues apply to quiche languages such as Java and C#.

### Reading list for C++

If you are going to be selling yourself partly upon your C++ skills, then you must read the latest edition of Stroustrup.

<http://books.global-investor.com/books/20551.htm?ginPtrCode=10202&identifier=a49d71be25a99088bb7a3d4aac82ff74>

If you are making the assertion that you are strong in C++, then you should read one, or preferably both of:

*Exceptional C++*

*More Exceptional C++*

By Herb Sutter, published by Addison Wesley.

Sutter takes the approach of taking specific aspects of C++ and drilling down so that you understand them at a deep level. Neither are good as your first C++ book, Stroustrup is still about the best for that.

Two good books on C++ for quants are:

*Financial Instrument pricing using C++*

By Daniel Duffy, published by Wiley.

This combines financial methods with patterns and is best thought of as your second book in C++ after you have worked through Stroustrup. Includes interfacing with Excel, important because a large percentage of C++ is front ended by Excel.

<http://books.global-investor.com/books/17081.htm?ginPtrCode=10202&identifier=a49d71be25a99088bb7a3d4aac82ff74>

*C++ Design Patterns and Derivatives Pricing*

By Mark Joshi, Cambridge University Press

Mark manages to get books into both the mathematical finance and quant programming sections and this is a relatively gentle, yet rigorous first book of C++ quant development.

<http://books.global-investor.com/books/17705.htm?ginPtrCode=10202&identifier=a49d71be25a99088bb7a3d4aac82ff74>

If you want practice understanding some of the more gruesome things that people do with C++, then the International Obfuscated C++ contest will provide you with a different perspective of how you build code.

<http://www.de.ioccc.org/whowon2005.html>

### A few basic C++ questions

What is Auto\_Ptr for?

Write a piece of code to reverse the order of characters in an STL string

Why would you use a const ref?

Is it safe to test two doubles for equality? Why?

What are lvalues?

### *Declarations*

We include the 2 general answers to the “what does this stupidly complex definition mean?” In general it of course means that either the interviewer or the person who wrote the code is an idiot, but neither tend to make a good impression, so we present an overview. A simple one, what ‘s the difference between pd1 and pd2?

```
double const * pd2;
```

```
const double * pd1;
```

Answer: None.

```
int *a,b;
```

```
typedef int* PINT;
```

```
PINT a,b;
```

\* or & only bind to the token next to them. So in the first declaration, we have a pointer and an integer. In the second they are both PINTs, ie pointers to integer

```
double * (* (*Ex1) (double const*)) [42];
```

Ex1 is obviously a pointer to a  
Function taking a pointer to a  
constant double  
and returning a pointer to an  
array of 42 pointers  
to doubles.

But you knew that anyway didn't you?

An algorithm:

```
double * (* (* Ex1) (double const *)) [42];
```

9 8 6 3 1 2 4 7

1: Find the variable name Ex1

**Ex1 is**

2. Look Right )

3. look left \*

**A pointer to**

4. Look right (

**A Function that takes**

**Parse arguments (goto 2)**

**That Returns**

6. look left \*

**A pointer to**

7: Look right [42]

**an array of 42**

8 Look left \*

**Pointer to**

9 Look left double

**double**

```
int& (*fn) ( const double * a , double& b );
```

Pointer to a function that takes a pointer to a constant double and a reference to a double and returns a reference to an integer.

*A Broken Class: Try to spot as many errors as you can*

```
class TimeSeries
{
    double * Price;
    double *TimeStamp;
    Tick * t;
public:
    TimeSeries(const size_t count) {
        Price=new double (count);
        TimeStamp =new double (count);
    };

    ~TimeSeries ()
    {
        delete Price;
        delete TimeStamp;
    }
protected:
    virtual double Volatility(void);
public:
    TimeSeries &operator+(TimeSeries Operand);
};
```

Feel free to mail Dominic@PaulDominic with answers.

### *Casting Off*

Finally fix the following snippets of code:

```
unsigned int * pint =  
static_cast<unsigned int*>(&i);
```

This won't even compile. Signed and unsigned integers are distinct types. Default in C++ is signed. You need reinterpret.

```
double * d =  
reinterpret_cast<double*> (&i);
```

Reinterpret will compile, but *bad* things will happen. You've cast the pointer, not the thing. Thus if you try to use the value pointed at, you will get some undefined value. If you assign to the pointer, it will be worse.

```
char *pc =  
static_cast <char *> (& uc);
```

This won't compile, signed chars are distinct from unsigned chars and chars. Again you need reinterpret.

It's also worth looking at C style casts of the form

```
Z=(double *) q;
```

If presented with a piece of code and asked to talk about it you should home in on C style casts as sources of cunning and vicious bugs. Even if the error isn't there, you will should earn a point for spotting them as bad coding technique.

## Dealing With Offers

### The Tipping Point

At some point during the process, it will switch from you selling yourself to them, to the bank selling itself to you. After what may be a protracted series of interviews, tests and meetings they have decided they want you. You now represent the payoff of a serious amount of investment in time and effort and they will try quite hard to make sure it *does* pay off. It's not uncommon for them to have interviewed anywhere between 10 and 20 people, and we hear tales of some firms sucking in 50-60 for every one they actually hire. It is also the case that your headhunter will be very close to actually getting paid, so he will want you to accept as well. A decent employer will not expect you to make a decision on the spot and will allow a week or two for you to choose the option that works best for you. Unless the other interviews are for very inferior jobs, then it's not wise to cancel them, no matter how much a HH tells you they are a waste of time.

### What is an offer?

Currently the market for quants is pretty good, so a verbal offer of a job is perfectly acceptable. But times change and it is only a real offer when the paperwork arrives from HR. Do not turn down your 2<sup>nd</sup> or 3<sup>rd</sup> best offer unless and until you get a piece of paper from your new employer. This will usually take far longer than you might expect, because of bank bureaucracy.

### Process

It is sometimes the case that there is no formal approval for the position yet, so your new boss has to go through internal processes to get it approved. This especially affects quants since your work will often be paid for and used by different groups and each has to both approve of you and the headcount that you will fill. This may take place in a short meeting soon after they see you, or over a few weeks as they see others and someone tries to coordinate the process enough that a consensus arises. As these people will be in more than one business area and sometimes different countries, this is not always rapid.

You may not be the first choice, but especially at the entry level we have many people going for many jobs, so they may miss the one they want, although of course this is not usually communicated to you. They then tell HR to send out an offer. They will have processes of their own and it is not exactly unknown for the first thing for HR to know of your employment is when they are told to make you an offer. In some firms the generation of contracts has been outsourced. This is done for cost reasons, not efficiency in time or stress. We have heard HR managers use the same language about getting their outsourcer to actually send the offer letter that you might hear from someone lobbying their government to change policy, with the same air of resigned low expectation.

All these steps may not sound like a robust or rapid process and sad to say that is quite often the case that things go wrong or take more time than it should. If you've got a headhunter helping you through this, we will (very gently) pester the various people to help move the process along and give feedback where possible. One person who applied personally without our help recently had to wait several months while the process ran its rather random course, the record is 5 months between verbal and written offer and we expect that to be beaten. If we're involved we can make this a little less stressful, but in the final analysis the bank will do what it wants, when it wants to.

### Turning down offers

You should be careful about turning down other offers until you are confident that it is a firm offer for the job you want most. They will typically set a deadline of 1-2 weeks for you to make up your mind and even if you have no other useful options, take some time to think it through. If you're applying personally, then you have to make sure you tread a path of keeping in their minds and really irritating them. No one likes nagging emails, no matter how polite you are. Either they remind them of the fact that's there's more bureaucratic work to be done, or they're waiting for someone else. The politeness we mentioned above is really valuable to you here.

Once you have an acceptable offer, then this can form a useful hedge when trying to get other firms to speed up their processes. Since you have a limit on your exposure, you can take a slightly more assertive line with the laggards. They will know that the offering bank will be putting pressure on you to accept and that you have limits on how long you can wait.

Some managers or headhunters will try and get you to accept extremely quickly. If this is the job of your dreams, then no real harm is done by accepting. But if you are being sold-to heavily then it's worth making sure you are making this big decision with the clearest view you can get. It is of course flattering to have a major financial organisation offer you good pay and really want you to join them, but do not let that sway you too much. One very senior manager at a global firm once described his work as "persuading smart people to join us". The bosses can be very persuasive when they want to be. It's fine to enjoy the moment, but as a new entrant to the market you can say that you are very keen but because you are new to this, you think it's best for all concerned if you make sure that it's the right thing for you.

Sometimes a headhunter may say that you have to accept today, or they'll walk away. This is not likely to be true, both the HH and the bank have invested quite a number of hours in finding you and they're not going to let that go to waste, unless you provoke them. Do try to get the manager's direct line.

### Spotting bad jobs

It's normal for a good percentage of your interview to focus on programming. However it is not unknown for people who think they are being interviewed for entry level quant jobs to get sucked into IT roles instead. It's worth asking what percentage of your time will be IT and what percentage analytical. Many people express to us the notion that they don't want to program at all. This is a worrying view of the work of a quant. More than one manager has described to us the first year of a quant's career as learning to code. As Peter Jaeckel, a famous quant put it, coding is how we turn maths into money. You must be prepared to be self sufficient in coding. Many firms have specialist developers for the final implementation, but you will still have to prototype and manipulate your own data.

You may not be a star programmer, but you have to attain basic competence, if you want to make a success of this career.

Questions you should get answers to:

- Where will I be sitting ?
- What is the name of the area which I will be in ?
- Who would be my boss on a day to day basis ?
- Whose group am I in ?
- What sort of work is the group doing now ?
- How will the work of the team change over the next year ?
- What other groups do they interact with, and how much ?

We're always happy to offer personal advice on how to evaluate offers via the website or email.

## Being Foreign

### We don't care

Quant finance is a business area where nationality or other superfluous characteristics are not of any real significance. Turn up to a Finance Focus or Random Walkers and you will see a very wide range of people, since the core issue is how well you do the work. Some managers at banks are quite smug at having succeeded in an environment they regard as a meritocracy. Banks are sensitive to discrimination issues, not least because it has cost them a lot of money in the past when they have got this wrong. Thus you may be asked about your age, race and some guess made about your sex. We say "guess" because a scary percentage of people who've seen Dominic's online details thinks he's female. At IBM the HR department became quite intense about "Dominic's maternity leave" at one point.

Some banks now directly ask applicants to fill in "diversity" forms ; this information is mostly to make sure that they can honestly say that although only 4% of their quants are women this is because only a tiny percentage of the applicants were women and similarly amongst various other groups. Like many other HHs we don't put irrelevant stuff on your CV, and our policy is that we don't change your CV at all.

### Visas

Most of the good jobs are in London, New York or Chicago, so a large percentage of people applying to be a quant, are not from the country that they want to work in. Banks will sometimes help with visa applications, but they generally don't want to, partly for reasons of cost, but mostly because it's more work. The more you can reduce the effort of hiring you, the better your chances.

If applying to a bank in London then you should look at the Highly Skilled Migrant Programme, which is neutral about your country of origin and is optimized for people whose presence brings financial benefit. We are now finding that it actually is a useful minor qualification in it's own right since it means that some official has actually checked your earnings and academics, and of course it mean they don't have to worry about visa hassles.

The system seems to be scrupulously fair, but alas it is run by a section of the British government whose own minister refers to as "dysfunctional" and "not fit for purpose". Thus you must make sure you don't expect them to think *at all*. You must include every bit of paper they ask for, and preferably support any fact by more than one written piece of evidence.

You may wonder why we make jokes about Accenture and EDS in this guide. Guess who does Home Office systems and consultancy ?

However, it's the least worst programme operated by any major government, if that is any consolation.

### Being there

At entry level, you are expected to do most of the running. That means coming to your target city and seeing as many banks as possible. This is not stress free, but you should allow for as much time as possible. Some banks will be flexible about when they see you, others won't. Some will go for initial screens by phone, but many managers really hate these and you will do your application far more good by investing in a ticket and a hotel room.

If you aren't a native English speaker, the sections on your CV where we talk about getting it reviewed are critically important.

Make sure you are contactable and if you have good reliable friend in your target city to receive mail, that can make life easier. All the things about being easy to contact are very true if you're operating remotely.

### Equal Opportunities

Banks really hate being sued for discrimination, it costs money, ties up lots of resources and looks bad. Thus all banks impose on their headhunting suppliers contractual terms that say they should not do this sort of thing. This means that some of them will send you an email directly asking you to disclose your sex, race, age etc. This is not something to be feared, it will not be seen by the hiring managers, or indeed your headhunter, and is there so that the bank has some sort of statistical view of the diversity of both applicants and those who get offered jobs.

At one market meeting where a large bank explained that it was now adopting this approach, some HHs who dealt with candidates from outside Europe and N.America were concerned that their people might be quite spooked by this, since in some places this sort of information is gathered specifically for the purpose of discrimination. We will not claim that big banks don't ever discriminate, but they are smart enough not to set up a large publicly visible system to do it.

P&D has two equal opportunities policies. One is a rambling, worthy and very dull document, lost in some subdirectory of Dominic's laptop. The other is our simple view that we do pimping for the money. Even if it were legal, discrimination would cost us money since we'd not be giving each vacancy our best shot, and thus lose the competition to fill a slot. We see losing money as immoral.

## Dealing with Headhunters

*Disclaimer: OK, we're HHs so apply whatever discount factor you feel appropriate, but we've tried really quite hard to be objective.*

We started a headhunting business because we saw that quants needed help from people who had hardcore experience of working in banks and as well as quant finance. This guide is part of our ambition to go beyond the standard of being a meat market to a resource that people turn to when going through a quite stressful and important part of their lives.

### Warning

On the Forums, P&D often refer to ourselves self-mockingly as “pimps.” We're fine about being called this. Most headhunters do not like this *at all*, so don't alienate the guy who might be getting you a job this way.

### How to spot a good headhunter

A good HH has good jobs and understands the work. At any point in time a HH may not have a role for you, simply because the market is so fragmented. A good HH will be honest about this and chat to you about the sort of direction to head in. The majority of HHs are sales people; they get paid for selling you, not for building up relationships beyond getting you placed. That focus can work to your benefit, since their objectives and yours are to get you into a job as soon as possible. He should be able to describe the job and should advance at least some idea why he thinks you are right for the job. A good HH will have read your CV and identified things from your experience that need to be expanded to make your application stand a bigger chance.

### How to spot a bad headhunter

Some HHs will spam your CV to every bank on the planet, regardless of which job you actually applied to. This is for their benefit rather than yours. They also try to push you into giving the names of the managers you've spoken to at other banks, as we see later that's not good at all. They may ask you to make them your “exclusive” HH, which is very bad for you at entry level. Some HHs are more than a bit “optimistic” about a job's quality. This ought to be hard to spot, but often it is surprisingly easy. This is because they lack the knowledge of banking to cover their tracks. Thus you may well find a job in housekeeping IT described as a quant job. Yes, really, that is a daily occurrence.

### Multiple applications

HHs get paid for finding people like you. But banks really don't want to get involved in dealing with different HHs who have sent your CV and both want money if you get hired. Some have a simple policy that if you apply twice, then your application is rejected for both. HHs hate that a lot and it makes them look bad as well as costing money. Some HHs won't tell you where they're sending your CV. This is bad news and can cause this sort of problem. Of course it may stop you applying to other banks because you don't know where your CV is being sent.

You should insist on knowing the name of the bank before they send in your CV, some will refuse. None of the motivations for doing this are good.

Some HHs will send your CV out without asking you and this causes all sorts of problems. It is deeply frustrating when a HH can't get hold of a good person to get permission to send and clients are not known for their patience. Typically it is some sort of race, with more than one HH chasing each job. In several countries, it is illegal to send in a CV without permission, but it does happen. We (P&D) don't do this at all.

### Carpet Bombing

Some HHs take this to an extreme. We have reports of senior managers getting a couple of dozen CVs from each spamhunter per week. It's hard to imagine that the cannon fodder actually agreed to be part of this human wave, or that it serves their best interests. But it does work for the HHs that do this, even if it harms the people they claim to be representing.

If you've been spammed into a bank, then it may be the case that only the spammer can represent you there. Since they work by carpet bombing, there is no notion of them trying to engineer the process, so it means you are stuck with them. You can see why they like this, but even then many banks have a policy that if two HHs submit the same candidate then you will not be considered at all. This sort of collateral damage may be acceptable to the spamhunters but can have drastic effects upon your career prospects. The flipside of this is that your contact details must work and be on your CV. We do get CVs without working contact details and it's not hard to see that that this does not advance their position at all.

You will change your employer or university at some point, and if you've given that as your email address it will mean that you stop getting future versions of the guide, and make it harder for us to get in contact with generally.

## Names

HHs need to keep their list of contacts at banks up to date in the face of continuous change. As above the HH needs to know if you've been put forward for the role he's currently working on. Sadly some HHs get a bit carried away with this and put pressure on newbies to give up the name of the managers they've been seeing. This can of course work against you, since he may have other people who he can use to compete against you for that job, so it is not a good idea to be too free with this. A HH only needs to know a little information such as the division and bank, "Fixed income, Credit Suisse" is easily precise enough to make sure there is not a clash.

Big banks are in some ways like a franchise operation. Different divisions rarely share recruiting processes and in some firms they have separate HR people. Also if you are currently in a job, you should be very careful about giving out your current manager's name. It does not make friends to have your boss pestered aggressively by a HH before you've got your next role.

This is of course easy for us to say, but if you're reading this guide, the odds are that you're new to this sort of thing. Some HHs are good at making you feel as if they personally are the only way you'll get a job and that you'll starve in some isolated village unless they rescue you. Remember of course that the HH that's pressuring you to give up names doesn't want the names he "owns" spread around either. Thus a good line to use is that you were told this information in confidence and that you will treat the other HH with the respect you treat this one.

But in the final analysis, there is no shortage of headhunters and if one is giving you a really bad time, it's not that hard to find another.

However, contact names are rather valuable information and if you feel a HH has done a good job helping you in a move, you may feel that you want to reward that with some useful work. Think of it as a tip for good service.

## Multiple targets

For your later jobs, you want a relatively high degree of precision and it can be entirely rational to deal only with one headhunter, or even none at all. However at entry level, it is a bad sign if a HH wants any sort of long-term exclusive on you. The market is too fragmented for any single source to offer the degree of exposure you need. If the HH is pushy on this, it is worth remembering that there are about the same number of HHs as banks.

### Exclusives

Some Headhunters will try and push you into dealing only with them. At entry level we think that is a truly bad thing for you. It is far more beneficial to the headhunter than the candidate and can cause serious harm to your job prospects. The simple reality of the market is that any given headhunter only sees a relatively small percentage of jobs on offer and at entry level considerable recruitment is done directly, without any search firm being involved. Also at this point there is significant competition for each role, so your chances of any particular application succeeding is not high enough to rely upon one or two shots.

At P&D we don't demand such exclusives for these reasons and although it does mean we spend effort on people who get placed other ways we are not in the business of damaging people's career prospects. A headhunter who wants exclusivity from a new graduate is not a good person. (We'd use stronger language, but we'd probably get zapped by spam filters.) Once you are established with a good amount of experience, then you will want to apply a more targeted approach and at the point it can be rational to deal with a small number of HHs, possibly only one.

### Multiple offers

You may get offered more than one of the jobs you apply for and sometimes this seems more stressful than actually trying to get a job. Some HHs will see their commission slipping away and try to put pressure on you. This is made worse by the fact that the bank has put a lot of effort into finding you as well and may blame the HH if you don't accept. You've got to take the job that suits you best. A good HH will of course put a case, but will realise when the game is up and store goodwill for next time. However, it's not always clear cut what you want and again P&D are quite happy to provide a sounding board for talking through the pros and cons. We do this quite a lot, even when we aren't the firm placing you; our view is that you'll remember good advice for next time.

Typically the ideal job will be a mix of the offers you have, especially in your first couple of jobs. So there may still be a value to the relationship with the HH that "came second." He will usually be keen to try and keep the game going, given that he's close to the final line and never ever forget that HHs are paid for placing people and they don't get paid if they don't.

### See it from their side

You should be aware that recruitment isn't just hassle for you, but that the people at the bank don't usually like it that much either and have other high priority tasks as well. Having to interview 10 people is not uncommon and at some banks anywhere between five and 12 people are involved in the process, which makes for a lot of work that they didn't want to do in the first place and won't earn them any bonus. So they will be quite sad about your rejection, and try to make you accept.

There are two basic scenarios, either you narrowly beat the next best person, or were the first one they found who was any good. If it is the second type, then they are going to try harder to suck you in and this can help the negotiations.

## Auctions

Banks do not like being drawn into auctions. The obvious reason is pushing the price up, but it's worth looking at how people make decisions on what they offer. Typically the hiring manager has to explain his boss that he believes that offering X will get you on board. Often he has had to make this pricing judgment before he's interviewed anyone, sometimes before even talking to a headhunter. This exposes him to risk and yet more of the recruitment process he so keenly wants to escape. This is a bank, so he will value his reputation as someone who can make good judgments about money and a process where he has to keep asking for higher levels of pay or rank for a new hire may risk making him look weak or foolish. Since these increases will require justification, an unrealistic set of expectations can easily be generated. If on the other hand he loses a good candidate because he wasn't allowed to pay for him, a politically astute manager may have an edge for a future discussion on what his people are paid.

There is also the delicate balance between what you pay people to join your teams vs. the people already there. In a rising market it's not impossible that last year's intake may be being paid less than is necessary to get good people now. Many banks try to keep pay rises to a single period each year, and that can amplify this situation more.

Thus hiring managers have strong incentives to avoid auctions.

## All or nothing

If two jobs are close, then it's worth seeing if you can make the second-placed one better. Although auctions are likely to fail, you can structure it so the "losing" manager can have one last shot. If you have a good HH, you can work together to see if there is a change in your level or pay structure which means you will definitely take the second-placed job. For this to work it's important that both the HH and second manager feel that this is a real deal. To get you a worthwhile change they will have to sell the idea and risk some of their reputational capital. If they think that even after getting the better offer you won't accept, then they won't even try.

## How to Quit

Often you can simply tell your boss you are going, wait a month or so and never look back. However there are a few obstacles that may well get in your way.

### Notice periods and Gardening Leave

A sign of the rising market in quant jobs is that notice periods seem to have gradually grown. This can slightly interfere with getting a new job, since often the new employer will want you to start sooner. In general most notice period clauses are enforceable, so you will need to check on these. However, it is rarely a big issue and of course if you're so valuable your firm doesn't want you to go, that looks good. However, it's worth telling your HH the terms, so that he can set the right expectation with your new employer. Some firms have "no compete" clauses and these are a naked attempt to improve their negotiating position when you leave. It is of course quite hard to get these removed until you've reached a stronger negotiating position with the bank.

Notice periods are usually enforceable, as are exclusion clauses on who you may move to. However, in legal terms it is technically difficult for them to get right. One of us was once offered a contract of employment that effectively meant that he could not work for any financial institution, the British government, the American government, or anyone who might ever do business with any of these. That essentially meant that he could only work in a coffee shop in Libya and then only if he didn't handle money. This is not enforceable, surprisingly enough, but most banks are not that crude, so please feel free to contact us if you get one of these.

### Negotiation

If you find yourself with an inconvenient notice period, then by far the best way forward is to talk things through with your boss. Some people take resignations very personally, but it's in everyone's interest to make this as painless as possible. Before you quit, look at your current work and try to work out which ones are important to be finished before you leave, which really require you personally and those that can be finished relatively quickly. Then make a hard, realistic estimate of how long it will take. The best deal for both sides is that you finish these jobs and go. You have an incentive to finish and your boss has some confidence it will happen. One of these jobs is to help recruit your successor, since of course you know what skills are required. As we say earlier, your boss won't be looking forward to the prospect of going through piles of CVs and interviewing people of rather variable quality. You can also write a good job spec and if you're dealing with the smarter end of HH then they will want to talk to you about the right sort of person. This helps make your ex-boss remain less stressed and means you can fade out leaving a good impression. The trick is to offer these things as part of a package. You are offering to leave well and in return they won't give you hassle over inconvenient parts of the contract. Most people in banks are quite honourable about these things, but they may be second-guessed by some more senior or generally awkward person in the bank. It is not exactly unknown for your manager to "remember" a different version of events. Thus you should confirm the agreement in a mail and make sure a copy is sent to your personal email. It is now rare for banks to "lose" inconvenient emails ever since a large bank got hit for a serious legal bill when it apparently genuinely lost some correspondence that would have helped its case. The courts apparently took the view that the bank could not have been as incompetent as it claimed. Clearly the judges had never dealt with an outsourced IT department.

### Buy backs

It's hard to work out what people are really worth and obviously part of your reason for leaving is that you think they have priced you wrong. If you are important to the team, then they will consider offering you more money. The same logic applies to the work you do and your conditions, or whatever else is driving you away. Some areas such as model validation are usually subject to quite high staff turnover because of a combination of all three, plus the feeling of many people who work there, that if they don't get out soon they never will.

However it is generally accepted that about 60% of people who are bought back after quitting leave within a year anyway. Leaving your job cleanly is worth doing well. The people you leave behind may crop up again in your career and it is far from unknown for you to consider going back to the same firm again later. For an example of how *not* to show your unhappiness with your current firm :

<http://www.wilmott.com/blogs/dcf/index.cfm/2006/5>

### Money

This is the easiest to fix, which may surprise those who've been told quite strongly that there is no money available. This is often an industry standard lie, as you may find when you hand in your notice. Money has the advantage that it's simple, to get more, your boss can make the case with his superiors or allocate money from some other pot. It may be hard to do this, but is usually simpler than altering your work. Usually they will top the offer you've just been made, though with one person we know his boss only offered half the difference. No, we don't know why they did this either, but as you can imagine it completed his resolve to leave. You have to ask yourself why you had to resort to this level of threat to merely catch up with the market. You can't realistically go through this very often, so the clock is ticking on you leaving anyway. Investment banks are the nearest thing to pure meritocracies on the planet and given that merit implies money, being underpaid means they don't value you, which is not a basis for a long-term relationship.

### Work

Your boss may offer to change the work you do. This is typically very hard for him to do, since the "bad" work still has to be done. It is also hard to objectively define and such promises are often made in good faith, but not delivered. If there is a specific thing you want to work on, then it's worth negotiating on. You may be offered the chance to move to a sexier group which is attractive, if true. This needs to be tied down well, a vague promise to try and get you more interesting work does not count for all that much.

## References

One obvious reason for being reasonable as you leave is that your boss may give you a reference. This is a murky legal area. Many banks are very hard line on giving references and require that all requests must be channeled through HR. This is to try and avoid the possibility of being sued and even then is not foolproof. One bank was sued after it appeared that they'd given a reference for the wrong person. Thus many have a policy of minimal references, typically stating little more than when you started and finished.

However HHs have the job of making sure you're right for the job and that often includes trying to get a verbal reference and some managers will contact your previous boss for an informal chat. This is a dark art. Your boss will usually be very wary of saying anything that gets him or the bank sued, but most people are quite reluctant to actually be dishonest. Thus a code evolves of pregnant silences, emphasis on words and euphemisms. This is far from perfect and quite a noisy signal, but is often all one has. The clarity of the reference is a function of how motivated your ex-boss is to say things and if he has strong views these come out.

## Useful Links

[www.wilmott.com](http://www.wilmott.com)

Lots of useful content, quant finance chat, articles, videos, job adverts. For the job seeker, the Brainteasers Topic is incredibly valuable.

<http://www.wilmott.com/blogs/dcf/>

Dominic's Blog, useful, tries to be funny.

[www.PaulDominic.com](http://www.PaulDominic.com)

Register your CV with us.

<http://www.gotw.ca/gotw/index.htm>

Interesting puzzles and points in C++.

<http://www.ieor.columbia.edu/forms/JobRiskColumn.pdf>

Derman's view on the way things are now.

<http://www.wilmott.com/blogs/>

The beta test for our new blogging environment, useful and interesting stuff to be found.

<http://www.fooledbyrandomness.com/>

Interesting thoughts on probability, finance and well pretty much everything.

<http://math.ucsd.edu/~crypto/Monty/monty.html>

The Monty Hall Problem.

<http://www.mindview.net/Books/TICPP/ThinkingInCPP2e.html>

Good free C++ book.

<http://www.nr.com/>

Numerical Recipes Home Site. This is a useful cookbook for number crunching. The coding style however is not one we recommend. At all. Even slightly. Don't do it, OK?

<http://archives.math.utk.edu/topics/>

Math Archives, lots in useful stuff.

[http://www.dartmouth.edu/~chance/teaching\\_aids/books\\_articles/probability\\_book/amsbook.mac.Pdf](http://www.dartmouth.edu/~chance/teaching_aids/books_articles/probability_book/amsbook.mac.Pdf)

Basic Probability.

[http://www.dartmouth.edu/~chance/teaching\\_aids/books\\_articles/probability\\_book/amsbook.mac.Pdf](http://www.dartmouth.edu/~chance/teaching_aids/books_articles/probability_book/amsbook.mac.Pdf)

Intro to Numerical Methods.

<http://www.7city.com/cqf>

The Certificate in Quantitative Finance.

## Next Steps

Feel free to send either of us an email (Dominic Connor, [Dominic@PaulDominic.com](mailto:Dominic@PaulDominic.com), or Paul Wilmott, [paul@pauldominic.com](mailto:paul@pauldominic.com)). It will be our pleasure to work with you!

We are now starting blogs on the [wilmott.com](http://wilmott.com) website as above and both of us can be reached through the private messaging system on [wilmott.com](http://wilmott.com).