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Learn from Commercial Aircraft Designers

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*What we call the beginning is often the end
And to make an end is to make a beginning
The end is where we start from.*

T S Eliot, Little Gidding, No. 4 of the Four Quartets, 1942

1. Introduction

A man walks into a Washington DC travel agent and has this conversation with the sales agent:

Agent: How can I help you Sir?

Man: I would like to book a flight from Washington to Santiago.

Agent: Before I check flight availability, I need to ask you a few questions. Can you please tell me about your attitude to risk?

Man (looking a little puzzled): My attitude to risk? What do you mean, my attitude to risk?

Agent: Yes Sir, have you fully factored into your decision to go to Santiago all the possible risks involved?

Man (showing signs of impatience): I'm in bit of a hurry and would just like to buy a ticket now if that's okay with you.

Agent: Sir, do you know the probability of in-flight loss of control due to extreme turbulence?

Man (his eyes opening a little more): Well no, actually.

Agent: Sir, you will know how risky landing is, but are you aware of how many accidents are caused while an aircraft is taxiing, loading or parking?

Man (face starting to redden): No, I am not!

Agent: Sir, did you know that you are twice as likely to die in an aircraft as a result of icing than as a result of a midair collision?

Man (having had enough and turning to leave): No I didn't, I think I'll walk to Santiago instead!

Agent (as the man storms out of the shop): Sir, are you aware how risky walking is? Have a nice day.

Now conversations of this kind do not take place that often, of course. The reason for this is that commercial airline flights involve very little risk. According to Boeing Commercial Airlines (2006), the accident rate on scheduled passenger airlines was 0.89 per million departures. This looks safe and, relative to other modes of transport, it is very safe. For a British citizen, for example, flying is 30 times safer than driving a car, about 550 times safer than walking, and nearly 800 times safer than a motorcycle.¹ Indeed, one can argue that air travel is by far the safest way to die! And the reason it is so safe is (pardon the phrase) no accident: aircraft designers have had to overcome people's understandable fear of the aircraft crashing. It does not take long for an airline passenger to know whether they are using a safe means of travel or not.

So why are pension plans not designed in the same way as commercial aircraft? At first sight, you might think that this is a strange question. It is, however, also a very instructive one. In fact, there are many similarities between pension plans and aircraft,

¹ Table 12.21, *Social Trends* 30 (2000) and *Social Trends* 36 (2006).

and designers of pension plans have much to learn from aircraft designers. The purpose of this paper is to spell out these lessons by using the framework of designing a commercial aircraft to illustrate how a personal defined contribution (DC) pension plan should be designed if it is to achieve its objective of delivering an adequate and secure pension in retirement for the pension plan member. As in the design of a commercial aircraft, there are trade-offs to be made, but these tradeoffs are much fewer and more clearly defined than you might have realised. More importantly, understanding the process of designing an aircraft will greatly improve your understanding of what an optimal DC pension plan might look like. It might also considerably simplify the task of those such as pension trustees and regulators whose task it is to oversee personal DC pension plans.

2. Please fasten your seatbelts: Lessons from the aviation industry

All journeys begin at the end. When you plan a journey you know where you want to end up. The airline flying you there also needs to know this, because it needs to use an aircraft capable of reaching the required destination and it needs to ensure that the aircraft has enough fuel to get there. It also needs to know when you wish to reach your destination. The airline gives you some other choices that you might consider important such as the class of seat and the type of food. But these choices, although important to you, are not really important for the airline, whose paramount concern is to get you to your destination safely. And the key word here is 'safely'. Safety dominates everything else: the best possible food and seat won't compensate much for a crash landing. Risk is the critical issue in the design of any commercial aircraft.

In the beginning, commercial flight was very risky and there was a lot of experimentation with new designs. But passengers demanded safety and very soon aircraft manufacturers and airline companies were able to give it to them.

This led to something quite remarkable: aircraft manufacturers soon started building very similar aircraft with almost identical safety standards. Sitting inside a modern commercial aircraft, can you really tell whether it is a Boeing or an Airbus? If you closed your eyes when you listened to the safety announcement at the start of your journey, can you really tell whether the aircraft was being operated by Emirates or Qantas? The key safety message is always the same: 'please fasten your seatbelts'. That's about the only safety precaution the passenger needs to take.

This should come as no surprise. When it comes to the tradeoffs between aerodynamic efficiency, safety and commercial viability, there are only so many ways to design an aircraft. Indeed, aircraft designers have become so successful in resolving these tradeoffs that most passengers give safety barely a moment's thought. So much so, in fact, that it is not uncommon for passengers to become impatient when their journey is slowed down to deal with safety issues.

Yet it took a great deal of effort to get to this point. Building a commercially successful aircraft requires advanced production processes, substantial research and development and a highly trained and integrated workforce comprising workers from a great many different highly skilled professions.

Having designed and built an aircraft, the aircraft manufacturer needs to persuade commercial airline companies to buy it. Any new aircraft chosen by a commercial

airline will need to satisfy a number of criteria that depend on the routes and market that the airline operates in, such as size, range, seating arrangements and cargo capacity. The aircraft chosen by the airline will ultimately depend on the manufacturer's ability to deliver a safe and reliable aircraft that best fits their market requirements at the lowest cost and on the most favourable financing terms.

The traditional design methodology concentrated on technical design and involved minimising gross takeoff weight (GTOW), the objective being to lower operating costs through reduced fuel consumption. It is also important to design aircraft that are financially viable, and this requires a multi-disciplinary design optimisation (MDO) approach that not only examines performance, but also incorporates financial modelling such as life cycle cost, direct operating cost and product-demand analyses. MDO also involves the evaluation of design risk – that is, how technical and financial uncertainty influence performance and value – and makes use of stochastic dynamic programming (DP) to aid decision making at each stage in the design process. MDO is, thus, a very complicated process that takes account of all manner of technical and financial issues, including the tradeoffs and major risks involved.²

And – to repeat – the reason why so much effort goes into the design of commercial aircraft is the *immediate* and very public reputational damage to both the designer and airline operator from a catastrophic design failure. Airline passengers might not know much about the technical issues of aircraft design, but they can certainly identify a catastrophic design failure when they see one. In this sense, they can be classified as 'intelligent consumers': they demand safety and they get it.

We now turn to investigate the current 'design' of DC pension plans.

3. How are DC pension plan investment strategies currently designed?

We can think of DC plans as having three stages – the initial marketing stage, the accumulation stage and the decumulation stage – and it is curious to note that there is currently very little connection between them. This is, in part, because the three stages are arranged by three different and disconnected groups of people: the sales agent of a pension plan provider who competes against other providers, the fund manager appointed by the chosen provider, and the annuity³ seller who often works for a life office that is not part of the same group as either the plan provider or the fund manager. The lack of connection between the three stages is also, in part, due to the fact that the customer, the potential pension plan member, generally has a very poor understanding of each stage and of the resources required and risks involved in delivering an adequate pension in retirement. Basically, the customer buys into a pension plan but has very little idea of what kind of pension income it will eventually deliver him.

The fact that pension plan providers are not dealing with 'intelligent consumers' gives them very little incentive to give much thought to pension plan design, let alone take an integrated approach to it. What typically happens when a sales agent first meets a

² For more on aircraft design, see, e.g., Peoples and Willcox (2006).

³ A true pension in the strict sense of the term always involves the purchase of an annuity because only an annuity guarantees the plan member a specified stream of income until they die. Any other type of fund is merely a form of long-term investment which involves the risk that the member will outlive their resources.

potential young customer it soon becomes apparent that the potential customer has little interest in starting a plan and little spare money to do so. To induce the potential customer to sign up, the sales agent will suggest starting the plan on the minimum level of contributions that the plan provider will accept or that regulation allows. In the case of UK stakeholder pension plans (regulated personal DC plans with capped charges), this might be as little as £20 (\$40) per month – a small fraction of the amount that a typical young person in the U.K. would spend on more important concerns such as fuelling themselves with booze.⁴ For a young person with credit card debts, a mortgage and an active social life to support, this might still seem like a lot of money, but it is in fact wholly inadequate to build up a decent pension entitlement. But this will be of no concern to the fund manager who in a DC framework has no target retirement lump sum to reach. When the plan member finally retires, the annuity provider will take whatever lump sum the fund manager delivers and offer an annuity based on current interest rates and mortality prospects, with no concern about the standard of living this might provide to the plan member. When the plan member eventually discovers how low his pension really is, it is by then too late to do anything about it.⁵

In terms of investment strategy, the one concern that the fund manager has about the customer is to invest the contributions in a portfolio of assets in accordance with the plan member's so-called 'attitude to risk' – an intimidating concept to the average 'man in the street' but also a nebulous concept even to most finance experts. Basically the fund manager asks him a few questions about his feelings about a more stable return profile that generates a lower expected return relative to a more volatile return profile that will (hopefully) earn a higher return, and on that basis advises him on an allegedly 'suitable' investment strategy. But such advice is woefully inadequate and has virtually no relevance to someone wanting to undertake an investment strategy that targets a particular pension level in retirement – let alone do so with any confidence in that target being achieved.⁶ Instead it reflects what Bernstein (1992) colourfully called the 'interior decorator fallacy', namely the argument that portfolios should reflect 'attitudes to risk' in the same way that interior decorators reflect the personal tastes of their clients.

Imagine if an airline provider was prepared to take on passengers with no regard for whether they were willing to put enough fuel into the aircraft, or if it regarded the only relevant safety issue to be the bumpiness of the ride without any regard to the passenger's chances of arriving to their destination safely? Perhaps we need to return to our airline analogy for more guidance.

4. How similar are pension plans and commercial airline journeys?

When you think about it, there is much in common between a pension plan and a commercial airline journey. The strategic investment strategy of a pension plan is

⁴Or so is alleged by the entertaining UK TV programme, "Booze Britain", which the authors of the current paper – having little experience of these matters – naturally take on trust.

⁵ Of course, he might be lucky in that cyrrhosis might have come to his rescue by then: risks usually diversify.

⁶ The advice offered is also generally ineffective as well as irrelevant. Most pension funds involve both active fund management and investment strategies that involve market timing but the evidence shows that the vast majority of professional fund managers produce negative returns from active fund management and are especially poor at market timing (see Lakonishok *et al.* (1992), Blake *et al.* (1999, 2002)).

analogous to the aircraft. The aircraft operator is analogous to the pension plan provider. The contributions into a pension plan are analogous to the aircraft's fuel. The climb stage of an aircraft's journey is analogous to the accumulation stage of a pension plan, and the aircraft's descent stage is analogous to the pension plan's decumulation stage. The safe arrival at the destination is analogous to the pension fund achieving its target outcome successfully. The actions of the pilot in managing the progress of the flight (e.g., in dealing with turbulence and cross winds) are analogous to the market timing or tactical asset allocation decisions of the fund manager. Air traffic controllers play the same role as pension trustees or regulators.

This comparison indicates some clear similarities between airline journeys and pension plans:

- Both seek to get you to a destination: in one case, a safe landing, in the other case, a comfortable retirement until death.
- Both involve the commitment of significant resources.
- Both involve managing highly complex risks.
- Both involve a climb and a descent stage.

However, there are also very significant differences, and these differences are highly instructive.

To start with, there is no uncertainty about the destination of an airline journey and the passenger does not — and indeed cannot — change his or her mind once the journey has started or alter the route to be taken. By contrast, with a pension plan, the destination of the journey (how much pension is desired in retirement), the anticipated length of the journey (the time until the member retires) and the route to be taken (the investment strategy) are generally much less clearly formulated when the pension plan journey begins, and can be easily changed afterwards. Whereas the airline passenger has no choices once seated down, the pension plan member can change his mind over virtually any aspect of his pension — such as the contribution rate, the investment strategy, the target retirement date, the decumulation strategy, and so forth. The need to accommodate this additional choice flexibility makes the design of a DC pension plan considerably more complicated than the design of an aircraft.

The time horizon with an airline journey is also much shorter, typically a few hours, compared with the 70-year or so journey of a pension plan. Aircraft designers *must* get the design right *before* the aircraft ever takes off, otherwise they will very soon lose their reputation, job or worse. By contrast, the designers of pension plans will have long since departed the scene by the time the member discovers whether his plan was well designed or not: the pensions that their plan members actually receive from their pension plans are not their problem. The incentives facing aircraft designers and pension plan designers couldn't be more different. Imagine if the plane crashed and the airline blamed the passengers for not taking more care about their flight plans, or dodged responsibility by saying that they should have read the small print in their contracts!

Another important difference is that airline passengers know that they need to get to the airport by a certain time if they want to catch their plane and reach their destination in time. On the other hand, the much longer journey of a pension plan offers plenty of opportunities to delay the journey's start and consequently end up with a lower pension by the time the retirement date arrives. There are a number of

reasons why people might delay pension saving: young people might have debts to pay off or be saving up to start a mortgage; they might have mortgages to pay or children to bring up; they might anticipate higher income in middle age which would enable saving for retirement to begin much later in the life cycle; or they might be willing to work longer before retiring if they discover that they would otherwise end up in poverty. People also delay pension saving because of the bounded rationality issues identified in the behavioural finance literature, which essentially boil down to them not understanding the full consequences of the decisions they are making.⁷ The pension plan is also just one part of an individual's life cycle financial plan and there are other factors to take into account, such as the desire to make a bequest to one's children (which influences the demand for life annuities in retirement), an individual's other wealth (such as his or her house), and the existence of social security (which influences the demand to save privately for retirement). In comparison, an airline journey is a one-off event that rarely impinges on other aspects of an individual's life.

There is also virtually no danger of an aircraft having insufficient fuel to reach its destination. Although there is a clear tradeoff in the design of a commercial airline between fuel efficiency and GTOW, there are very, very few cases of aircraft crashes caused by running out of fuel. And, of course, it is very obvious with a commercial airline flight that no improvement in fuel efficiency can compensate for insufficient fuel to reach the destination. Indeed, with an aircraft it is unthinkable to consider possible improvements in fuel efficiency in order to compensate for fundamentally inadequate fuel provision. For its part, a pension plan does involve an important tradeoff between investment strategy and contributions: a low-risk investment strategy with high but stable contributions, on the one hand, or a higher-risk investment strategy with lower but more volatile contributions, on the other. Nevertheless, as with airline fuel, we would argue that no increase in investment risk can compensate for fundamentally inadequate contributions if a particular target pension outcome is desired. This leads us to us is one of the key problems in the design of current pension plans: the misguided attempt to use investment strategy to compensate for fundamentally inadequate contributions.

Another instructive difference relates to the relationship between the climb and descent stages of an aircraft journey, on the one hand, and the accumulation and decumulation stages of a DC pension plan, on the other. Whereas the climb and descent stages of an aircraft journey make up a seamless whole, there is an almost complete lack of integration of the accumulation and decumulation stages in the current design of DC pension plans. The fund manager takes whatever contributions he receives and invests them in line with the member's declared level of 'risk aversion' – even though the fund manager knows that members have no real idea what that means and few of them have any better idea themselves. ('Risk aversion' is, as real experts know, simply an artificial construct in the mind [sic] of a financial economist.) The member's 'risk aversion' – whatever that might really mean – is simply a tick on the box and otherwise doesn't matter to the fund manager: he has no incentive to deliver any specific fund level, because he has been set no target to do so. At the start of the decumulation stage, the assets are typically handed over to a life assurer and, depending on the size of this lump sum, the age and sex of the member and whether or not a spouse's pension is also required, the life assurer provides a life annuity to the

⁷ In addition, most young people just don't even want to think about their pensions. As Woody Allen once aptly observed, there are some things worse than death, such as spending the evening with an insurance salesman.

member. Again the life assurer has no incentive to deliver any specific retirement income, because again he has been set no target to do so: he or she simply quotes a rate and the member's accumulated pension fund is converted into an annuity stream implied by that rate: the consequences to the plan member are irrelevant. All this contrasts markedly with the design of an aircraft where the climb and descent stages are an integral part of the overall design because the aircraft is designed for the ultimate purpose of reaching a destination safely. Leaving aside the awkward issue of whether you had any idea what you had signed up to when you ticked the incomprehensible boxes many years ago about your 'risk aversion', imagine being told by the captain of the 'climb plane' that it is time for you to transfer to the 'descent plane', but that the descent plane was miles away and the airline had overlooked how you were going to get to it! And what if you had started the journey about forty years before and couldn't remember what you had agreed to or (as happens to some of us) couldn't jump from one plane to another as you thought you might once have been able to do in your youth!

And finally, there is the difference between the competency of the passenger and that of the pension plan member. The airline passenger who knows nothing about how planes or the laws of thermodynamics operate is at no disadvantage relative to an expert: all he needs is to know where he wants to go and the airline and flight to book. The airline passenger can therefore be treated as an intelligent consumer who knows what he is doing. Unfortunately, when it comes to financial matters and especially financial products extending over long periods of time, many consumers are clearly not well-informed or well-educated; bounded rationality and behavioural biases also become important. These problems are especially relevant and difficult in the case of products as complex as pensions. The assumption that we can regard the pension customer as a fully rational and adequately informed consumer is therefore much less tenable. In this case, there may be a role for some kind of guide or supervisor to act on behalf of members as a surrogate 'intelligent consumer'. As regards pensions, this role might be filled by pension trustees or (possibly) by regulators.⁸

5. Conclusions

We hope we have persuaded you that pension plan designers have a lot to learn from airplane designers. A well-designed commercial aircraft journey involves very few passenger instructions, little more than 'please fasten your seatbelt': all the risk

⁸ There are also other difficulties that should be noted: (1) The laws of aerodynamics are known and unchanging, whereas our understanding of the processes generating asset returns is still poor. No one would expect an individual contemplating an airline journey to have a deep understanding of the laws of aerodynamics, yet individuals considering joining a defined contribution pension plan are in effect expected to make very complex investment choices that implicitly presuppose a knowledge of asset return processes that even experts do not have. (2) There is issue of economies of scale. Such economies are an integral feature of the design of a commercial aircraft and are essential to keep prices down and demand high. While the super rich can afford their own jumbo jets, there is no feasible mass market for single individual commercial airline flights. With pensions, on the other hand, there is a large market for personal DC plans, but these plans are very expensive (in terms of charge extraction via reduction in yield) to design and manage. This is especially so if the plans are voluntary and have to be marketed directly to individuals separately. This, in turn, raises difficult issues of how much choice is feasible in retail DC pension schemes, not to mention the underlying problem of what a 'good' retail DC scheme might look like in the first place. Both these issues reinforce our main point that the design of good DC pension plans is considerably more complicated – to say the least – than the design of commercial airliners or even rockets to the moon.

management has already been taken care of. We can envisage that a well-designed pension plan in the future will be similar. Like an aircraft journey, it will be designed from back to front (that is, from desired outputs to required inputs) with the goal of delivering an adequate targeted pension with a high degree of probability. Once a few key parameters about the plan member are known, the pension plan provider can be left to do what is needed to get the plane safely to its destination, so long as the member believes in the benefits of the pension journey he is making and is willing and able to maintain the required contributions schedule. There will still be risks, of course, but these will be as well understood and as well managed. Once this has happened, we will be in a position to think not of pension plans, but of pension planes, with the equivalent safety instruction to 'fasten your seat belts' being simply 'just sign up and we will take care of you'.

Current pension plans fall well short of this ideal. Indeed, to the extent one can say they are 'designed' at all – the adjective 'design' implies a conscious intent or purpose, and some degree of forethought about the eventual outcome, none of which seem to be apparent in most current pension plans – they are currently 'designed' the wrong way round, that is from front to back, beginning with the question 'how much would you like to contribute to your pension plan?' before going on to frighten potential members with the next question 'what is your attitude to risk?' The intimidated customer signs up, pledges £25 (\$50) a week and the salesman reassures him that he has secured his long-term financial future. No one then gives any serious thought to the eventual outcome until the customer gets a very rude shock forty years or so down the road. By that stage, there is nothing that can be done and those most responsible – and especially those who designed the pension plan in the first place, and if they are lucky, the salesman too, hopefully commission- and (even better) genitals-intact – will have long since gone off to meet their Maker.

Hands up all those who are happy with Stone Age pension plans that could have been designed by Barney Rubble?

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