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Survivor Bonds: A Comment on Blake and Burrows

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Abstract

This article offers a critical assessment of the "survivor bonds" (SBs) proposal recently put forward by Blake and Burrows, which calls for the government to issue bonds whose coupon payments are contingent on the proportions of retirees surviving to particular ages. It suggests that the proposal has considerable merit and discusses the circumstances in which SBs would be useful risk management tools for insurance companies. It also discusses alternatives such as reinsurance, hedging with life contracts, dynamic hedging, and other forms of survivor derivative. Finally, it evaluates and rejects the argument that SBs should be issued by the state.

Introduction

In a recent article in the *JRI*, David Blake and William Burrows (BB) make the intriguing suggestion that the government should help insurance companies hedge their mortality risks by issuing "survivor bonds" (SBs)—bonds whose coupon payments would depend on the proportions of the population surviving to particular ages (BB, 2001). BB argue that such bonds would be ideal hedge vehicles for insurance companies wishing to hedge mortality risks and that they should be issued by the government rather than by the private sector.

The starting point of the Blake-Burrows argument is the familiar problem of how an insurance company should hedge (or otherwise manage) its aggregate mortality risk. BB point out that insurance companies' profitability on annuity portfolios is heavily dependent on subsequently realized mortality, and insurance companies stand to make considerable losses if mortality improves unexpectedly. Insurance companies are thus naturally short mortality improvement risk, and they have no particularly good hedges against this risk. BB go on to argue that insurance companies are generally in a poor position to absorb this risk themselves and that managing their asset portfolios to match these risks is costly and, in any case, provides an imperfect hedge (BB, 2001, p. 340).

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Their solution is for the government to issue SBs, bonds "whose future coupon payments depend on the percentage of the whole population of retirement age (say 65) on the issue date still alive on the future coupon payment dates" (*op. cit.*, p. 344).[1] The coupon payments on these bonds would be very highly correlated insurance with the companies' annuity payments, so the bonds should provide a very good hedge against mortality improvement risk: if annuitants live longer, the insurance companies would then make annuity payments for longer periods, but they would also receive greater offsetting coupon payments on their SB asset positions.

This imaginative proposal has much to commend it, but it also needs further clarification. In particular, we need to clarify alternative ways of managing aggregate mortality risk—reinsurance, other forms of hedging, and so on—to get a better idea of the possible role and comparative advantage of SBs as a mortality hedge. We should also consider other mortality derivatives such as survivor forwards, futures, options, and swaps. Furthermore, the argument that SBs (or other survivor derivatives) should be issued by the government is open to question, and there are good reasons why their issue would be better left to the private sector instead.

AN ANALYTICAL FRAMEWORK

To examine the proposal more closely, it is helpful to consider the two basic instruments, annuities and SBs, in their simplest possible forms. The first of these is a pure simple annuity, which is a contract that pays a fixed amount to each annuitant still alive at some future time t.[2] Assume that an insurance company will sell a large number of annuities to diversify away individual mortality risk and so leave itself exposed only to aggregate mortality risk. Thus, if p_t is the proportion of annuitants still alive at t, its actual outgoings at t will be cp_t, where $c > 0$ is some fixed amount, and its expected outgoings, cp_t^e, will be proportional to p_t^e, its expectation of p_t. The firm then arranges to finance its future payments by purchasing a bond to pay it cp_t^e at time t. When

[1] If the principal purpose of SBs is to hedge insurance companies' aggregate mortality risks, then the relevant base should not be the surviving proportion of the original population, as BB suggest, but the surviving proportion of original annuitants. The reason is that the latter, not the former, is the insurance companies' underlying risky variable against which they seek a hedge. SBs conditional on the proportion of surviving annuitants would therefore provide a better hedge than contracts conditional on the surviving proportion of the original population. BB themselves do not address the issue of which base provides the better hedge but argue that the base should be the proportion of the surviving population and not the proportion of surviving annuitants, on the grounds that the latter would involve a "substantial cross-subsidy" to longer-living and usually richer annuitants from less long-lived and usually poorer general taxpayers (*op. cit.*, p. 345, n. 12). However, this argument implicitly concedes the presence of the basis risk—the slippage between the two bases—that makes the proportion of surviving annuitants a better hedge against insurance companies' mortality exposures. Of course, BB are correct that there would (generally) be a tax-subsidy effect *if* SBs are issued by the state, but I would also point out that no such effect arises if SBs are issued privately. Hence, I would interpret their tax-subsidy argument as another reason (in addition to those listed below) why SBs should not be issued by the state.

[2] One can regard real-world pure annuities as portfolios of simple pure annuities, each promising to make the same fixed payment at a different, but equally spaced time: if we divide the future into time periods 1, 2, 3, etc., the first pure annuity would make the fixed payment at time 1, the second at time 2, and so on.

t arrives, the firm receives cp_t^e, pays cp_t, and makes a profit/loss of $c(p_t^e - p_t)$.[3] If there is no mortality improvement, then p_t will be equal to p_t^e, and the firm will realize a profit of zero at t. However, if mortality improves unexpectedly, then $p_t > p_t^e$, the firm's annuity payments will be higher than expected, and it will make a loss of $c(p_t - p_t^e)$. The insurance company has a short exposure to survivor or mortality-improvement risk, and our main concern is how the firm should manage this risk exposure.

A survivor bond is a contract promising to pay cp_t at time t, and BB correctly point out that the insurance company can offset the mortality exposure on its annuity portfolio by purchasing such a bond instead of a conventional one. The cash flows at t would then be the outflow on the annuity (i.e., $-cp_t$), plus the inflow on the SB (i.e., cp_t), so the net cash flow would be certain. The purchase of the SB hedges the company's exposure to survivor risk, because the annuity and the SB have equal and opposite exposures to it.

ALTERNATIVE METHODS OF HEDGING SURVIVOR RISK

Reinsurance

However, SBs are not the only means of hedging this risk, and we need to consider these alternatives before we can establish how useful SBs might actually be.[4] One of these alternatives is reinsurance, which is standard practice for other risks such as weather or catastrophe risks to which insurance companies generally have a net exposure.[5] Reinsurance can be implemented through traditional reinsurance methods or through risk-sharing in the capital markets. Capital market reinsurance is particularly attractive not only because of the vastly greater capital available in the capital markets, but also because mortality risks have low or negative correlation (or beta) with traditional risk factors such as financial market indexes, and capital market participants are generally keen to acquire exposure to such risks. It follows that if insurance companies can manage weather and comparable risks through reinsurance, then they can also reinsure mortality risks in similar ways: reinsurance is thus an obvious alternative to purchasing an SB.

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[3] Strictly speaking, we should also take account of the profit made up front, when the annuity is first sold: the firm sells the annuity, purchases a zero-coupon bond to offset the expected annuity payment, and pockets the difference as profit. However, this up-front profit plays no role in our discussion and can safely be ignored for present purposes.

[4] One also has the option of securitization: for insurance companies to sell annuity portfolios in the same way that banks now routinely sell portfolios of consumer or credit-card loans. Securitization of bank loans enables banks to diversify their risks further (e.g., so a regionally based bank can cut down on its regional loan exposure and acquire more national or international exposure) and reap benefits from specialization of functions (e.g., banks can separate out the functions of originating loans and servicing them). Annuity securitization would benefit insurance companies in similar ways and would provide an alternative means for them to offload their mortality improvement risk exposure.

[5] As an aside note that the fact that private-sector parties appear to be able to handle weather and similar risk exposures despite insurance companies being naturally short in them undermines the argument that being naturally short mortality (or any other) risk is *in itself* a sufficient argument for government intervention to create the relevant market—in this case, for government issue of SBs.

Hedging Survivor Risks With Life Contracts

Another way to hedge the survivor risks implicit in annuity contracts is through the sale of life contracts. The key point here is that the sale of a life contract gives an insurance company a long position in mortality improvement risk, which offsets the short position that results from the sale of an annuity. For example, suppose a firm sells a batch of life contracts, and the individuals concerned live longer than expected. The insurance company benefits because it gets premium income over a longer period than expected and because its promised death payouts are delayed. Conversely, if individuals die faster than expected, premium income is reduced, death payouts are brought forward, and the insurance company loses. Sales of life contracts thus create the opposite mortality exposure to annuity sales, so enabling insurance companies to use one to offset the mortality risk created by the other. Life contracts are natural hedges for annuities.

Dynamic Hedging of Survivor Risks

A third alternative is dynamic hedging. Remember that annuity providers are essentially taking a view about the proportion of annuitants who will still be alive by a certain future date t: an insurance company sells annuities on the basis of a certain forecast of what this proportion will be, and new information subsequently becomes available every so often that enables the company to revise this forecast. In addition, as t approaches, the forecast gradually converges to the realized value.

The insurance company can use this new information to dynamically hedge its annuity exposure. For example, if news arrives that leads the company to revise upward its expectation of the proportion surviving at t, then the company could purchase a zero-coupon bond (or strip) maturing at t to meet the higher expected annuity payments and in so doing re-hedge itself and accept a loss equal to the price of the bond; if information arrives that leads the company to revise downward its expectation of the surviving proportion, then it will sell a zero-coupon bond (or strip) maturing at t, re-hedge itself, and realize a profit from the sale of the bond. The company then revises its expectation of p_t every so often and buys or sells a zero/strip bond accordingly, until t arrives and the annuity payments are made. If these revisions are sufficiently frequent, this dynamic hedging strategy will produce an outcome approximately the same as that obtainable by purchasing a survivor bond.[6] In other words, the company can approximate an SB position by a strategy of dynamically hedging its annuity contracts.[7]

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[6] There is a natural parallel here with conventional forward and futures contracts. If a survivor bond is a forward contract on the underlying mortality variable (i.e., the proportion of survivors at t), the dynamic hedging strategy outlined here is akin to a futures contract—albeit one without any participating clearinghouse. Furthermore, since it is well known that forwards and futures tend to have much the same price if the underlying variable is independent of interest rates, and since this condition holds here, one can infer that the two approaches should have much the same price. The two approaches should therefore be pretty much the same, absent transaction costs and similar factors. I say more on survivor forwards and futures later.

[7] In passing, it is helpful to note that a dynamic strategy also implies that a firm realizes its mortality profits or losses dynamically, as "news" about the proportion of annuitants who will survive gradually comes in. If news comes in that mortality is likely to be lower than anticipated, the firm realizes its loss by purchasing more regular bonds to cover its greater

USES OF SURVIVOR BONDS

To motivate the use of SBs, we must compare them with each of these alternatives. Reinsurance tends to be expensive to arrange, whether through traditional or capital-markets routes, and most insurers use it to lay off large amounts of idiosyncratic risk to primary investors. Purchases of SBs, by contrast, would enable insurance companies to lay off mortality improvement risk to a much wider range of counterparties, at a lower arrangement cost than traditional reinsurance. SBs are also more suitable instruments to be traded on secondary markets.

SBs are also much more flexible than life contracts as hedging instruments. Although insurance companies' life and annuity businesses have offsetting mortality exposures, it is very impractical to coordinate these two lines of business to minimize their combined mortality risk: their annuity and life businesses will be subject to all sorts of different, and sometimes independent, influences (e.g., one might be doing well while the other is doing badly, etc.), and exploiting their mutual hedging potential can only be one of many other business considerations. As a result, an insurance company will typically still have some net mortality exposure, and it will seek other instruments to manage this exposure.

Relative to dynamic hedging, an SB has the advantages of a (fairly) static hedge: an issue of SBs requires one single transaction, while dynamic hedging requires a large number of them. If transaction costs are a consideration—which, at some level, they must be—then a purchase or sale of an SB might be better than, or at least complementary to, a dynamic hedging strategy. Trading in SBs would take some of the pressure off a dynamic hedging strategy and enable the firm to cut back on the number of dynamic hedging trades carried out. An SB also has the advantages of lower operational risk and greater transparency, thus making an SB hedging policy easier to implement and easier for the insurance company management to monitor.

There is thus plenty of scope for insurance companies to benefit from trading SBs even after they have done their reinsurance, taken advantage of any practically exploitable offsets between their annuity and life businesses, and implemented dynamic hedging strategies to keep down their mortality exposures.

A MARKET FOR SURVIVOR BONDS?

There is also the deeper question of demand and supply in the SB market. As we have seen, many insurance companies would be natural purchasers of SBs. SBs would also offer investors, especially fixed-income and hybrid investors, an attractive new investment outlet: a bond with a higher yield than a comparable Treasury bond, but with lower credit risk and less business-cycle correlation than many corporate bonds. SBs would therefore offer fixed-income investors an ideal means of further diversifying

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expected liability on the maturity date, and vice versa, in much the same way as it would realize its losses by immediate marking to market on a futures contract. A strategy of dynamic hedging also implies that the firm does not take out, say, a 20-year position, and discover at the end of that period that it may have incurred a huge loss on that position. Barring a sudden shock such as the discovery of a "cure to aging," mortality improvements will be gradual, and realized profits or losses will be gradual as well; furthermore, a firm can always alter (or even eliminate) its mortality exposure at any time.

their portfolios. Hence, it is easy to visualize a strong demand for SBs from insurance companies and institutional and other investors.

But who would want to sell SBs? Part of the answer is that firms with long exposures to mortality improvement—such as large retailers, equipment manufacturers, pharmaceutical companies, and other firms geared toward the elderly market—might wish to hedge their mortality exposure by selling SBs. Some insurance companies might also wish to sell them. If a company's life business is large relative to its annuity business, that company could be long rather than short mortality improvement and so profit when mortality unexpectedly improves. Such firms would be potential sellers of SBs, and one could imagine an intra-insurance-industry market for SBs—much like the inter-bank market for bank loans. Nonetheless, it is easier to envisage a large demand for SBs rather than a large supply, and in such circumstances of "natural excess demand" one must presume that the price of SBs would respond appropriately: that the price would be higher (and yields lower) than would otherwise be the case to choke off demand and encourage supply. However, remember that similar arguments can be made for other derivatives markets that still manage to function quite effectively: for example, certain markets for agricultural derivatives can sometimes be said to have "natural" excess supply, and such markets still clear, but at a low price.[8]

OTHER SURVIVOR DERIVATIVES

As we have seen, one can regard an SB as a forward contract in which some fixed amount, the initial contract price, is exchanged for a stochastic cash flow at t conditional on the realized value of the underlying stochastic variable p_t. However, one can envisage other survivor derivatives as well:

- European survivor put or call options based on the same underlying variable, maturing at t: Relative to a forward or SB contract, such options would enable the holder to benefit from upside risk while being largely protected against downside risk, or vice versa. The holder of an option with a long exposure to mortality improvement would benefit and exercise the option if mortality improved strongly, but the holder could let the option lapse and lose only the option price, if mortality turned out to be high. Such an option might be ideal for a company that sought to achieve (or avoid) an asymmetric mortality exposure. However, the disadvantage of this downside (or asymmetric) protection is that the holder must pay more for it: hedging with options is more expensive than hedging with forwards or futures.
- Futures contracts based on survival forecasts: Organized exchanges could offer futures contracts based on credible forecasts of p_t (e.g., forecasts that could be published every month by reputable actuarial associations). These contracts would work the same way as other futures contracts: if forecasts went up, those who were long on mortality improvement would take their profits, those who were short would take their losses and put up more margin, and so forth. Such contracts would enable the parties involved to trade mortality risk easily, with low

[8] Once an SB market was established, one could also count on other parties to enter on both sides, particularly speculators and hedgers, so boosting market liquidity and drawing further traders into the market. The market for SBs would then receive a further boost if (or when) markets for other mortality derivatives took off. Traders in these markets would then use SBs as hedges: mortality swaps dealers would use SBs to hedge their mortality exposures, etc.

transaction costs and regular marking to market (or taking of profits or losses), and have the usual advantages and disadvantages of futures relative to forwards: the futures contracts would be standardized and more liquid, have negligible zero credit risk (because the counterparty would be the exchange), and have profits marked to market; forward contracts would be tailor-made and less liquid, have more credit risk, deferred realization of profit or loss, etc.

- Survivor swaps: Institutions interested in mortality risks could swap mortality-contingent payment streams in much the same way that many firms now routinely engage in interest-rate and similar swaps. Such swaps would provide firms with low-transactions-cost methods of hedging mortality improvement risk or speculating on it. They would also enable users to radically alter their exposures. For example, an insurance company that was overexposed to mortality risk might swap some of its mortality exposure for some of the equity exposure of a capital markets institution that wanted to reduce its equity exposure and acquire mortality risk. Mortality swaps would also be useful for firms wishing to diversify or internationalize their mortality risk exposures or wishing to circumvent legal restrictions on the assets they are permitted to hold.

Each of these survivor derivatives thus has its own distinct comparative advantage. Together with SBs, they would make it easier than is currently the case for insurance companies to obtain their desired mortality risk exposures. At the same time, these instruments would also make it easier for other parties to acquire and trade mortality risk and, in so doing, improve the liquidity of mortality-risk markets.

SHOULD SURVIVOR DERIVATIVES BE ISSUED BY THE STATE?

Granted that there may be useful niches for SBs (and/or other survivor derivatives) to fill, the next question is whether they should be issued by the state. BB argue that they should, and one argument they put forward is based on the Arrow-Lind theorem (1970) on social risk bearing, which

> shows that by dispersing an aggregate risk across the population (of taxpayers) as a whole, the associated risk premium can be reduced to zero. The government could therefore issue survivor bonds at a lower yield (namely, the risk-free rate) than any private corporation could. . . . [Whereas] shareholders will demand a risk premium, . . . the government can act as a risk-neutral player. (BB, 2001, p. 345)

However, this argument is open to objections:

- The Arrow-Lind theorem does not apply. Some key assumptions underlying the application of the Arrow-Lind theorem to this problem—in particular, that taxes are costless to collect, that each household bears an equal share of the tax burden, and that there are no relevant distribution effects—will all be violated. Instead, the state would acquire a net exposure to mortality risk that does not diversify away among taxpayers, and the cost of the state bearing this exposure would not be zero.
- Capital markets are better suited than any government to bear and share risks—indeed, this is exactly what the capital markets are for. While a state will only

diversify risks among a group of conscript participants (i.e., taxpayers) within its own jurisdiction, markets can diversify internationally, and therefore more broadly, among parties who have chosen to participate in the risks concerned. The fact that participants in financial markets are willing, whereas taxpayers are not, also suggests that risk-sharing through financial markets is more efficient.[9] This conclusion is further reinforced by the argument that the markets can—and government participation-through-taxation cannot—provide participants with the risk exposure that suits their differing individual circumstances and preferences.

BB also make the argument that insurance companies cannot mimic the outcomes attainable using government-issued SBs: more precisely, if firms self-insure, then they will still be exposed to loss if they misjudge survival rates, but they will avoid such losses if they use SBs instead, and this matters because insurance companies can (and do) go bust, while governments (at least in Western economies) do not (BB, 2001, p. 346).

However, this argument does *not* provide a justification for the government issue of SBs because it ignores the costs of government intervention (i.e., the costs of collecting taxes, etc.), ignores the other options available to insurance companies to manage or hedge survivor risk (i.e., hedging with life contracts, dynamic hedging, securitization of annuities, etc.), and ignores the potential for private-sector parties to create and trade survivor derivatives for themselves. If the private sector could benefit from survivor derivatives, then one would expect them to appear without government intervention to create them—and the government intervention would be unnecessary.

Critics might respond by raising the familiar textbook "justifications" for government intervention—that there are public goods, externalities, market "failures," intergenerational equity or risk issues, and so on, to which some form of state involvement might be an appropriate response. However, each of these arguments is itself open to debate: relating to the first three, one must ask where and what is the public good, externality or market failure in this context, and why would a public good/externality/market failure—if there is one—justify intervention?[10] The intergenerational argument is open to the objection that governments have an incentive to put the interests of cur-

[9] Note also the related issue of the most appropriate way to look after the interests of future generations, and one can make a reasonable argument that the interests of future generations are most appropriately looked after by private individuals' bequest motive, by which wealth is handed down, usually through the family, from one generation to another. However, there are also those who argue that the interests of future generations would be better served by some form of government intervention. Leaving aside the costs of government operation (i.e., the welfare losses of taxation, etc.), this latter argument is open to the objection that governmental institutions are only meaningfully answerable to current voters and not to their unborn future descendants. Governmental institutions are therefore not well placed to look after the interests of future voters where those interests might conflict with those of current voters, and much evidence exists that real-world government policies often heavily discount the interests of future generations (e.g., in many environmental and energy policies, in state-pension planning, etc.).

[10] This argument for state intervention requires that the public good (or externality or market failure) exists *and* that its existence justifies some intervention, and neither of these can be taken for granted. Thus, a public good must satisfy specific characteristics (nonexcludability, etc.), and, even where they exist, public goods can often be provided through conventional

rent voters ahead of those of future voters, and so on.[11] Nonetheless, there is also a sense in which these issues can only be properly resolved in the context of an explicit economic model. To give an example from a related area, proponents of state deposit insurance have long sought to justify such intervention by reference to the seminal "sunspot" model of Diamond and Dybvig (1983), while critics of deposit insurance have argued that that model is inherently flawed and does not in fact justify deposit insurance (e.g., Dowd, 2000). But either way, the model provides a framework within which that debate can be pursued further and more explicitly than would otherwise be possible. I would therefore suggest that anyone who supports state intervention—in the issue of SBs or in any other area—should write down an economic model that he or she thinks justifies a preferred policy. Potential critics can then examine it and respond appropriately.

Finally, there is the argument that intervention must be necessary to bring survivor bonds into being because the private sector has not (yet) produced them itself. But this argument is also debatable. Many financial innovations are conceived in principle before they are implemented in practice, and at any point between conception and implementation they are open to exactly the same argument (i.e., that there must be a market "failure," or government intervention must be required, because they have not yet been implemented). This same argument could therefore have been made about many other financial innovations—including bank loan securitization and the emergence of credit derivatives—that have since become firmly established without government intervention to "make them happen." The fact that a particular innovation has not yet occurred does not in itself constitute an argument for government intervention to bring it about.[12] Any good new idea, including that of survivor derivatives, should eventually take off—but we have to give it time.

CONCLUSIONS

The idea of survivor derivatives is still in its infancy, and a number of issues still need to be sorted out before schemes for such derivatives can be regarded as fully opera-

"market" mechanisms: a good illustration is Coase's famous example of the successful private provision of lighthouses in Britain (Coase, 1974). Similar arguments can be made for externalities (e.g., that they must be Pareto-relevant, etc.), and most "'external effects" are not. These issues are pursued further in Cowen (1988), who gives a number of detailed case studies and counterexamples where the existence of public goods and externalities is not sufficient to justify government intervention. Some arguments for market failure are considered in "A Market for Survivor Bonds?" and in the next paragraph below. For further examples, see Mitchell and Simmons (1994).

[11] See also note 9 above.

[12] BB also discuss the possibility that the government should be involved in the issue of SBs in pursuit of its own vested interests in health and longevity (BB, 2001, p. 345, n. 13). However, as they themselves point out, the introduction of government-issued SBs creates perverse incentives, since the government would then have an interest in *reducing* longevity to keep down SB coupon payments. This is a particular problem in countries with substantially socialized health systems (e.g., in Europe), where the state bears much of the costs of treating the elderly and will bear even greater costs in the future as people live longer and demand ever more expensive medical treatments. The government's conflict of interest on longevity is another good reason for preferring to keep the government out of the survivor-derivatives business.

tional. Nonetheless, the core idea is a very sound one, and one can already identify some of the uses to which they might be put. When the time is ripe, it is therefore entirely possible, and even likely, that markets for survivor derivatives—survivor bonds, forwards, futures, options and swaps, and annuity securitization—will take off, and eventually become as familiar as comparable instruments such as credit derivatives are today.

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