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ABSTRACT

We make the case for the U.S. government to issue a new security with a coupon tied to the United States' current dollar GDP. This security might pay, for example, a coupon of one-trillionth of the GDP, and we propose the name "Trill" be used to refer to this new security. This new debt instrument should be of great interest to the Government for its stabilizing influence on the budget (as coupon payments fall in a recession with declining tax revenues) and for its yield, based on our valuation. Standard asset pricing analysis also suggests that Trills would enable important new portfolio diversification strategies and, in contrast to available assets that protect relative standards of living in retirement, Trills would have virtually no counterparty risk. We believe there would be a lively appetite for the Trill from institutional investors, public and private pension funds, as well as the individual investor.

Keywords: GDP-linked bonds, aggregate risk, income risk, inflation-indexed bonds, MacroShares, U.S. Treasury, Treasury Inflation Protection Securities (TIPS), intergenerational risk sharing, international risk sharing, hedging, portfolio diversification, market portfolio

JEL Classification: H63

Perhaps the most pressing issue today for pension fund managers and, thus, investors saving for retirement, is the availability of assets that will provide shares in the real wealth of the nation to fund stable payments to pensioners, preferably assets with none of the counterparty risk that has loomed so large in the recent financial crisis. Traditionally, a large part of any pension plan's holdings has been in fixed-income assets such as long-duration government bonds. Pension funds typically hold about 25 percent to 30 percent of their net assets in fixed-income and inflation-protected bonds, highlighting the importance of very low risk securities. The United States government currently issues a range of such debt instruments, including short-term and long-term debt with either nominal or real coupon payments. The largest portion of this debt is short-term, nominal-fixed coupon, which serves a primary objective of the federal government's debt strategy: providing a source of low-cost funding for its operations. But these debt instruments do not allow pension fund managers to attain an optimal risk exposure for pensioners.

In this study, we make the case for the U.S. government to issue a new security; one that we believe would offer great direct benefit to U.S. citizens, the operations of the U.S. government, and the rest of the world as well. This new security would have its coupon tied to United States' gross domestic product (GDP) in current dollars. This security would be long term in maturity, ideally even perpetual. Such a security would be attractive to private and public pension funds around the world, as it would provide access to a broader range of income-earning potential in the U.S. We believe this new debt instrument would also be of interest to the Government for its stabilizing influence on the budget (as coupon payments would fall in a recession with declining tax revenues), mitigating the rollover risk attendant with short term debt in a way that currently available long term government debt cannot.

A small-denomination GDP share might pay, for example, a coupon each year of one-trillionth of that year's GDP, or about $14.40 at current levels. On this basis, we propose the name "Trill" be used to refer to this new security. Similar to shares issued by corporations paying a fraction of corporate earnings in dividends, the Trill would pay a fraction of the "earnings" of the U.S. Given the characteristics of GDP growth, our valuation of the Trill indicates its yield would be very attractive to the issuer, the U.S.

government, and, for the same reasons, would be a useful new source of income to investors who want exposure to income growth and protection against inflation.

Why Investors Need Trills

Because nominal GDP would be used to determine the Trill's coupon value, the inflation-protection properties of the Trill would resemble that of the US Treasury's Inflation-Protected Securities (TIPS). Inflation protection alone would be sufficient to generate interest in Trills comparable to that which exists for TIPS. Further interest would be generated by an additional desirable characteristic; namely that their coupons and principal would respond to variations in GDP. Trills would protect relative standards of living in retirement, since they are a constant share of GDP, in contrast to TIPS, which purchase a declining real share of a growing GDP over time.

Creation of Trills can be motivated in terms of models of intergenerational risk sharing. There is a small literature that considers the benefits of intergenerational risk-smoothing through long-lived assets. Some of this work does not involve government debt (see, for instance Peled 1984, Allen and Gale 1997, and Geanakoplos 2008) though much of this literature does investigate the impact of government debt on welfare. Gale (1990) shows that uncertainty in an OLG model leads to incompleteness and allows for government debt issuance to be pareto-improving through its impact on intergenerational transfers. In particular, long-term debt may provide much better insurance than short-term debt. Improvements in welfare may not be surprising with incomplete markets. In this case the government can provide innovative financial securities and complete markets. Even if markets are complete, however, in an overlapping generations (OLG) model the competitive equilibrium may be inefficient so that government debt or transfers can still improve welfare (see, for instance, Gale 1990 and Demange 2002). Bohn (1990) makes a strong argument for government liabilities that provides a hedge (for the government) against macroeconomic shocks to smooth tax revenues and maximize welfare. He finds that shorting the stock market is one way this could be accomplished. Of course, issuance of Trills is a natural way for the government to do this, and we return to this issue below. Bohn (1999, 2001, 2003) builds on the Diamond (1965) model to show that in an OLG neoclassical framework, government use of debt is

potentially welfare improving, because of inefficiencies in the allocation of risk across generations, in particular the problem that future (unborn) generations are naturally excluded from financial markets. Kruger and Kubler (2006) apply the overlapping generations model of Paul Samuelson (1957) to show that government interventions analogous to Trills can be Pareto improving. Trills can also be motivated in terms of models of international risk sharing, Athanasoulis and Shiller (2001).

Of particular note in light of recent market turmoil, Trills would have virtually no counterparty risk, in contrast to currently available assets that protect relative standards of living in retirement.

The recent trend to pension funds investments in "real assets" (Jacobius 2009) is sign of a thirst for long-duration assets that reflect the real economy in ways that are different from conventional financial assets. Matching cash inflows and outflows is at the heart of any pension fund investment strategy since pension obligations stretch out over decades. Many plans offer benefits that are linked to wages as they accrue and to inflation once they are in pay. Investing in real assets and inflation-protected bonds are two ways these plans seek to generate steady, inflation-protected income flows.

There is a wide range of assets currently available to large pension plans. These include: municipal, state, and federal government bonds; international government and real-return (inflation-protected) bonds and debt; domestic and foreign publicly traded equities; derivatives (such as equity swaps and futures, exchange-traded futures contracts and foreign-exchange forwards); commercial paper, bank notes, mortgages, private equity, real estate and infrastructure assets. A reasonable person might wonder, what more does the market need?

Although the availability of publicly traded debt, equity and derivative securities, as well as private equity assets, makes for a fairly comprehensive menu with which to diversify a portfolio, these securities represent a small fraction of the wealth of the nation. Wages, salaries and supplementary labor income make up roughly two-thirds of the U.S.'s GDP, but trading on claims to these income flows is essentially closed off to markets and investors. While it is true that government debt is a claim on future labor income, the majority of this debt is short term and produces income flows that are fixed nominal coupons. Claimants to this debt may benefit from avoiding the repercussions of a

slowdown in the economy, but they do not enjoy the gains from a growing economy as would claimants to a security such as a Trill, which would grow with GDP.

Corporate profits after tax represent approximately 10 percent of the GDP. Without access to direct claims on future labor income, which makes up the bulk of the remaining income flows and hence the bulk of the wealth of the nation, pensioners who invest only in stocks are restricted to the return from holding claims on corporate profits. They are thus very far from holding a diversified portfolio.

It is possible that the stock market will not perform as well in the 21st century as it did in the twentieth century. For example, during the 20th century baby boom, the capital/labor split of corporate income may have favoured the relatively scarce resource of capital. But in the 21st century, labor may become relatively scarce, and returns to capital may decline. If afforded the opportunity to invest in Trills, investors could insulate themselves from the risk of declining returns to capital and ever more expensive labor costs.

The target-income funds, or life-cycle funds, that are newly popular are designed for people in a specified age cohort. For example, the AllianceBernstein 2035 Retirement Portfolio invests for those planning to retire in 2035, while the Fidelity ClearPath 2045 Sr A plan invests for people who want to leave the work force in 2045. These funds have high equity exposure when their participants are young and reduce the exposure as they age. In the future, they could fulfill their basic mission better by taking a dynamic portfolio strategy involving Trills. Ideally, they would hold a relatively small proportion of their portfolio in Trills (or even short Trills) when their participants are still young, so as to reduce their exposure to the risks of the economy and their labor income. As participants approach retirement, when their welfare increasingly depends on investments rather than labor income, the funds would invest progressively more heavily in Trills.

Holders of 401K Plans could also benefit from options that are tailored to their individual circumstances. The 401K could, for example, offer investments in target-income funds that optimize Trill holdings.

As we outline below, we can, subject to some assumptions, estimate the return in the future to holding a Trill. Standard mean-variance (return versus risk) optimization over asset classes, including the estimated return to holding Trills, suggests that Trills might

allow investors a return very nearly as high as the S&P 500, with half the volatility. Indeed, investors gain a much higher return and lower volatility than if Trills are excluded from the mix. This mean-variance optimization produces an optimal portfolio composition of 28 percent of assets in long-term bonds, 38 percent in the S&P 500 index and 34 percent in Trills. Thus, the addition of Trills to the asset mix available today would likely have a dramatic impact on investor portfolio composition and investor well-being.

Why Treasury Should Introduce Trills

The benefits and the costs to Americans more generally are of primary concern when considering the introduction of the Trill. While a positive argument can be made for *investors* holding this new security, an important question is whether issuing Trills make sense for the *issuer*, the U.S. government. Is the investor's gain the taxpayer's loss?

To understand if a case can be made for issuing these new securities, it helps to consider the current objectives of the government with respect to issuing debt obligations, and look forward to the challenges of managing the nation's wealth. The U.S. government issues very few classes of securities, but ensures that the issued securities are both easily marketed at favourable yields and traded in liquid, well-functioning markets.

In the abstract, the Treasury might be considered to have a variety of missions, not so simply defined as just the funding of government activities. Ideally, Treasury must also worry about managing the risks of specific government activities, of dealing with intergenerational risk sharing, with reducing systemic risks, with helping the central bank in lender of last resort functions, with providing risk management opportunies for individuals, with encouraging international spreading of risks, with managing precommitment and default risks and political risks, with managing the balance of payments and exchange rate, with managing the reputation of the national debt among international investors, with considering the effects of the real national debt on the nation's ability to raise funds in future emergencies such as depressions, wars and natural catastrophes. There is today no canonical theory of all the missions of the Treasury. We imagine that the issuance of Trills might play a role in fulfilling many of these missions of the Treasury, but we cannot consider all of these issues here.

The *stated* mission of the US Treasury, found in the *Strategic Plan of the Treasury FY 2007-2012*, is:

Serve the American people and strengthen national security by managing the U.S. Government's finances effectively, promoting economic growth and stability, and ensuring the safety, soundness, and security of the U.S. and international financial systems.

Another explicit statement of the U.S. government's debt policy also found in the *Strategic Plan of the Treasury FY 2007-201*2:

The Department of the Treasury provides the American public with cost-effective, efficient and secure management of federal finances …The Treasury Department will develop a cash balance financing portfolio model to minimize interest costs and other risk factors, such as operational and rollover risk.

Taking these statements as given, we can proceed a little more definitely to consider the role of Trills. The main objective of the federal debt strategy is to raise stable and low-cost funding to meet the operational needs of the Government. An associated objective is to maintain a well-functioning U.S. government securities market, which helps to keep debt costs low and contributes to efficient capital markets by providing important pricing and hedging tools.

Stability and low-cost are actually competing goals, as the short-term securities issued by the government are typically cheapest to issue, but also exhibit the most volatility in yield over time and rollover risk. We will discuss the second priority - maintaining efficient financial markets -- after careful consideration of the cost and stability of funds associated with issuing Trills.

The Cost of Borrowing

To preview our results, the cost of Trills would likely be little more than 1.5 percentage points above that of short-term government debt (the return to Trills would be from the coupon and the capital gains). The competing goal of *stable* funding for the government clearly favours the introduction of the Trill. A fiscal planner, concerned with the cost of servicing debt in a recession, would view the Trill as a natural hedge against

budget shortfalls – the coupon paid on the Trill will track government revenues as both rise and fall with the GDP.

What features enable low-cost funding? Basically, any security that moves risk away from the investor and onto the issuer will be more highly valued by investors and therefore entail a lower cost for the issuer. Still, it seems likely that the cost of issuing Trills would be higher than that of issuing fixed-coupon, inflation-protected debt.

The Treasury Inflation Protected Securities (TIPS) already issued by the U.S. government have a number of features that are attractive to investors. There is virtually no default risk with TIPS (likely no more than a Trill would pose), there is little or no inflation risk (which is similar to the inflation protection afforded by the Trill) and, unlike the coupon from a Trill, the TIPS income is fixed in real terms. In good times and bad, an investor will get a known, risk-free real coupon.

The coupon from the Trill, on the other hand, will vary with the GDP of the economy. This is good for the issuer, the U.S. government, because when the economy is expanding rapidly and the Trill pays more to the investor, the government has better tax revenues and hence better ability to pay. When times are bad, the Trill pays (relatively) less, which is also good for the government because this is exactly when tax revenues fall.

For some investors, in good times there is less need for a big coupon from the Trill – all of a domestic investor's income sources are likely paying off in good times. In bad times for the U.S., when the domestic investor may really need the money, the Trill is paying less. In the language of financial economists, the Trill exposes domestic investors to systematic risk and insures the government against it. If the Trills are held only by domestic investors, these investors will need to be compensated for bearing this risk. To the extent that the Trills become held by foreign investors, whose GDPs are not highly correlated with U.S. GDP, the compensation will likely be lower. For still other investors, including pension funds, this disadvantage comes with an important offsetting advantage: that Trills will provide higher incomes when their wage-indexed liabilities are growing more quickly in booms, and when Trills pay lower incomes, in slumps, pension fund wage-indexed liabilities are also growing more slowly.

These cross-cutting considerations make it difficult to estimate whether Trills or regular fixed-coupon nominal debt will be cheaper for the U.S. government to issue. Trills

provide inflation protection while fixed-coupon, nominal debt provides fixed (albeit nominal) income flows. A more formal way of estimating the cost of capital associated with issuing Trills is through an examination of the U.S. GDP's historic record. By treating GDP as a dividend and using tools for pricing income-producing assets, we can estimate the price and return of a Trill.

Athanasoulis and Shiller (2001) considered the pricing of portfolios of claims on GDP from a dynamic stochastic general equilibrium model that considered Trills as taking their full dimensions, as if every person on earth took optimal positions in Trills in all countries and one riskless asset, subject only to specified limits on the number of markets. (See also Shiller and Athanasoulis 2000 and Athanasoulis, van Wincoop and Shiller 2002). To achieve this general equilibrium theory, they made some strong assumptions about utility functions and the absence of other assets, and produced what they called the constant absolute risk premium (CARP) model that enabled them to estimate risk premia to various portfolios of claims on GDP. The only data input to their econometric model was time series observations on the real GDPs of the countries of the world and their populations. With this model, no country's securities can be priced without considering the relation if its GDP with each other country's GDP, since the risk sharing opportunities cannot be evaluated if any country is missing from the analysis. Since the model was internally rigorous, it allowed estimation of the welfare gains of introducing these new assets.

We take here a shorter-term, and more immediately practical, focus. We do not wish to assume that the Trills are launched full blown to all individuals in the world, nor do we wish to disregard the presence of other assets, nor to disregard political barriers to establishing such risk management at such a global level. Thus, in this paper we sought to take a more practical, partial equilibrium, approach to pricing trills, from the work of Donaldson and Kamstra (1996) and Donaldson, Kamstra and Kramer (2009).

The valuation of any income-producing asset first requires an estimate of the risk premium[2] demanded by investors. Standard techniques to evaluate an asset's risk exposure rely on the availability of returns to that asset. To begin, one must estimate what a Trill

[2] The risk premium is an *ex ante* premium or extra return (or price concession) investors demand when they decide to invest in risky assets like equities instead of risk-free debt.

might be worth, and then estimate how returns to a Trill would vary over time and co-vary with other risky assets. We apply a risk premium equal to that used to discount risky equities as a proxy for the premium investors would expect when holding a Trill. This estimate is likely too high (a claim to the GDP of the U.S. is a more diversified asset than a claim to cash flows from publicly traded equities) but it provides a sensible starting point to place an upper bound on the required rate of return and a lower bound on the price of a Trill. We employ an extension of the Gordon Model (1962) developed by Donaldson and Kamstra (1996) to perform our valuation exercise. Our sample ends in 2007, and therefore excludes the remarkable behavior of the stock market after the subprime crisis, a potential problem we will return to in the appendix. The Donaldson and Kamstra (DK) technique permits extremely complex scenario analysis that is otherwise infeasible, considering scenarios in which the income-flow growth rates and/or the risk premium never settle down and possibly influence each other as well. Details on this procedure and related issues can be found in the Appendix.

Figure 1 displays DK prices and associated yields for the S&P 500 index (prices in Panel A, yields in Panel B) and what they would have been for Trills (Panels C and D) from the late 1950s to 2007, with prices normalized so that each investment is worth one dollar in 1966. Panels A and B also plot realized market prices and yields for the S&P 500 index which we will use to evaluate the success of the DK procedure. If the DK procedure is helpful, then the prices and yields it produces should capture the main features of the market price and yield—rapid appreciation over the past 40 years with remarkably low dividend yields.

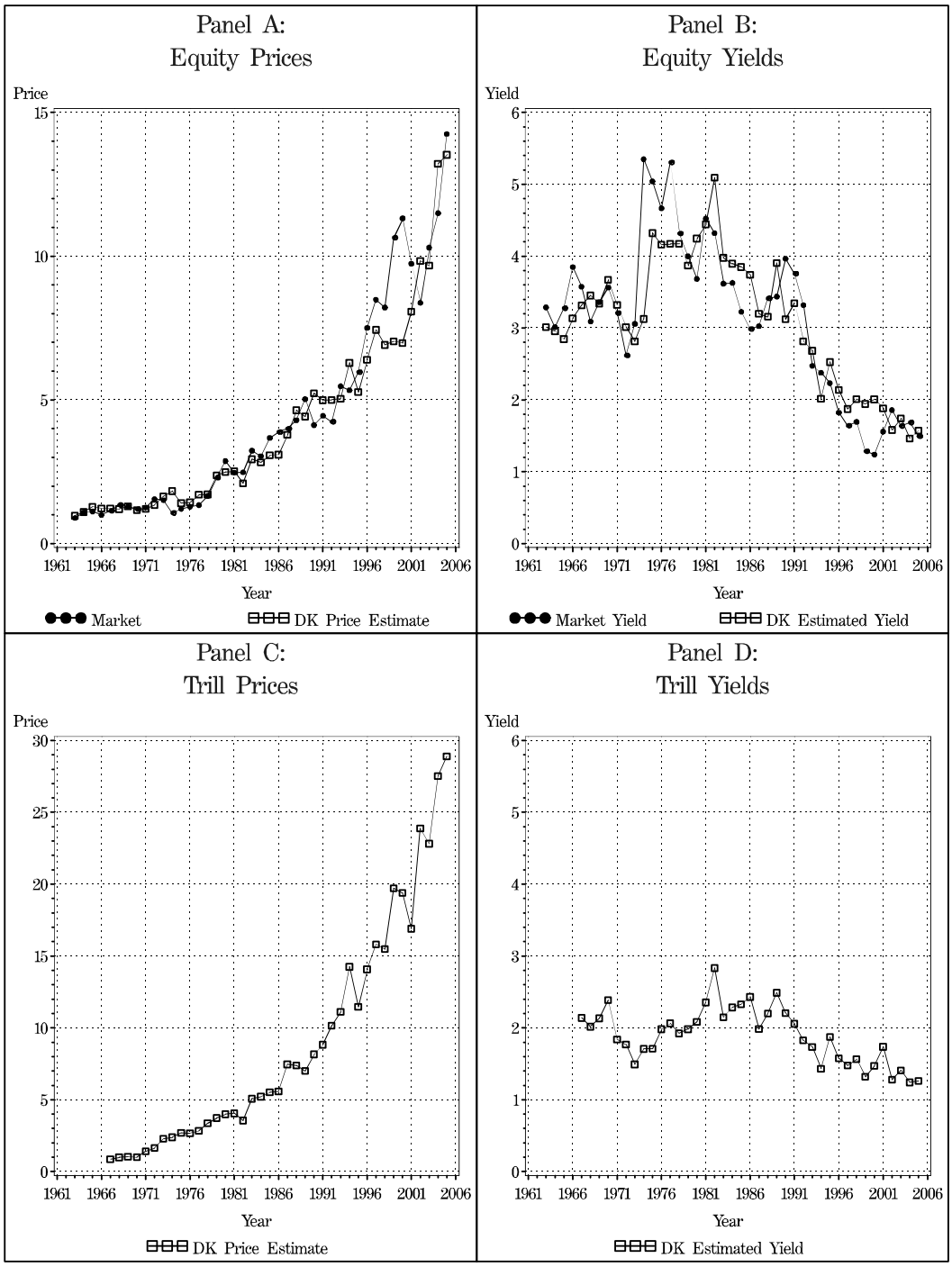
Although the estimated S&P 500 prices (the line indicated with squares in Panel A) fall well below market prices (the line indicated with solid dots in Panel A) for the late 1990s, the estimated and actual prices generally move together. Indeed, the actual and fitted yields are highly correlated with a coefficient of more than 0.85. Altogether, application of the Donaldson-Kamstra approach to pricing the equity market lends some confidence to the notion that the DK estimated prices for the Trill will be a good first approximation to market prices, and that the estimated yields should not be wildly off the mark.

Panels C and D of Figure 1 display estimated prices and yields respectively for Trills from the late 1950s to 2007, again with prices normalized to equal one in 1966. As we saw for the S&P 500 index, prices increased dramatically in the 1990s. The similarity to the S&P 500 index is not coincidental and comes from the favorable interest-rate environment, which affects identically the value of S&P 500 index and the Trill.

The more dramatic increase in the plotted (estimated) price of the Trill relative to the S&P 500 index comes from the relatively rapid increase in the cash flow that would have been realized (had such an investment been available) from owning a Trill, combined with the low fade rate[3] of this cash flow growth.[4] In general, good news (or bad) is expected to persist for the U.S. economy longer than for public equity. Hence, the strong economic growth of the 1990s would have led to very sharp increases in the value of a Trill, even sharper than that of the S&P 500 index.

[3] Fade rate refers to the speed of a reversal to a baseline level.
[4] An increase in the growth rate of the Trill's cash flow is expected to persist much longer than that of the S&P 500 index given the greater persistence of GDP growth relative to dividend growth

Figure 1


Panel A:
Equity Prices
Price
Year
Market
DK Price Estimate
Panel B:
Equity Yields
Yield
Year
Market Yield
DK Estimated Yield
Panel C:
Trill Prices
Price
Year
DK Price Estimate
Panel D:
Trill Yields
Yield
Year
DK Estimated Yield

Given these results, it is likely that had Trills been available we would have seen very aggressive appreciation in their price over the past half century, perhaps even greater than we have seen for the S&P 500 index. The coupon yield on Trills (that is, the cash flow-to-price ratio) would have been lower than the dividend yield on the S&P 500 index, though the two would have been similar in magnitude. If anything, the estimated prices and yields for the Trill are conservative, underpricing the asset and overestimating the required yield, because this method takes no account of the particular benefits these securities will offer to investors, pension funds in particular, that currently have no access to this type of asset.

Another way to calculate the cost of capital relevant to issuing Trills is by estimating a Capital Asset Pricing Model (CAPM) beta for the Trill; calculating the degree of correlation between the return on the Trill and the market return (typically proxied by the overall stock index). While the return to a Trill *itself* should be the appropriate measure of the total market return, since the Trill represents a claim on the GDP of the entire economy, we use a classic CAPM estimation for the purposes of evaluating the risk and appropriate reward for holding a Trill. Our analysis measures the amount of the S&P 500 index return that is in excess of the Treasury bill return as the market excess return. This CAPM regression produces a beta of approximately 0.25, showing that the Trill is clearly a low-risk asset. The CAPM estimate of the required rate of return for the Trill is 7.5 percent, indicating a risk premium of only 1.5 percent. This is consistent with our suspicion that the equity risk premium we applied to generate the Trill's returns is likely too large.

So even before taking into account the additional willingness to pay of investors who would find Trills uniquely attractive, we conclude that the cost of Trills would likely be low, and possibly less than some outstanding government securities. The competing goal of *stable* funding for the government, moreover, potentially counterbalances any higher cost of borrowing. Georges (2003) shows that considerations of the overall budget balance through the business cycle can impact optimal debt management. Traditional analysis of debt management emphasizes debt maturity structure as a choice between low

cost but volatile short-term debt and higher cost but more stable long-term debt. Georges (2003) points out that a fiscal planner would typically be most concerned with the risk that the cost of servicing debt jumps up at a time when the government budget can least afford it, say in a recession. This echoes a motivation for the offering of real return bonds, the value of diversifying government debt obligations to reduce the risk of a budget crisis, even if this diversification increases the average cost of borrowing to the government.[5] Liability management issues lead directly to the Trill as a natural hedge against budget shortfalls – the coupon paid on the Trill will track government revenues as both rise and fall with the GDP.

Variants on the Trill could include bonds with coupons based on national income or consumption, or even tax revenues. Like GDP, these economic statistics are commonly revised over time. For example, a given year's final GDP figure may not be known with certainty for some time. Nevertheless, dividends are routinely paid to shareholders based on preliminary corporate earnings estimates, not final figures restated years later. Choosing a fixed date on which to determine the Trill's coupon, say three months after fiscal yearend, and using the real-time GDP estimate available at that time, would enhance investors' understanding of the income stream provided by a Trill.

Maintaining Efficient Financial Markets for Currently Available Debt Instruments

The impact of Trills on financial markets is an important consideration from the perspective of the U.S. government. How would room be made for Trills without compromising traditional debt markets? It may be difficult to substitute Trills for conventional debt as it comes due. Capital markets rely on the term structure of U.S. government nominal debt as a reference point for pricing other fixed-coupon nominal debt, and as a hedging instrument. This debt is also used to park wealth by foreigners seeking a safe haven from political and economic instability.

The current financing needs of the U.S. government may make it easy to find room for a new debt instrument. It is also possible to make room for Trills in the regular issuance of government securities by using the proceeds from the sale of Trills to fund

[5] We are grateful to Nicholas Le Pan for his insights on the process leading up to the adoption of real return bonds (RRBs) in Canada.

federal government obligations that are currently unfunded, thus ensuring that the net indebtedness of the government does not increase.

Potential Uses for Proceeds from Sale of Trills

The most obvious use of the proceeds of Trills in the nearer term would be to fund federal government obligations that are currently unfunded. A precedent for this change would be the Canadian government's 2000 move to fund future employee pensions: rather than adding a book-keeping entry to its unfunded pension liabilities every year as previously, the Canadian government now issues additional funded government debt and is building a pension fund administered by an arm's-length board to invest in order to pay future pension benefits. The U.S. government has many unfunded obligations on its books – for example, the fair value of social security benefits. Establishing investment funds to cover these and other liabilities is arguably desirable in its own right, and would permit the federal government to issue large amounts of Trills without affecting its net indebtedness or reducing outstanding securities of other kinds.

Another potential use of the proceeds from the sale of Trills would be an investment fund similar to those established to manage budget surpluses in many countries around the world, such as Norway's Government Pension Fund, and Canada's Alberta Heritage Fund. The government would want to invest the proceeds from the sale of Trills to earn sufficient returns to cover their coupon payments. To the extent there are surpluses and shortfalls in the income flows from such a fund, these could be used to stabilize government revenues. In this way, government cash flows would be less vulnerable to macroeconomic surprises. Such a fund would face governance challenges. We recommend that the proceeds from issuing Trills, pooled in a sovereign wealth fund similar to Norway's, should be managed at arms length from the government, with a clear mandate to promote diversification and long-run stable returns.

Should the U.S. government decide to issue Trills, we expect other countries to follow suit over time, just as Finland's introduction of indexed bonds in 1946 led to many others following suit. The availability of Trills issued by countries around the world would present an opportunity for nations to buy each other's Trills, using the proceeds from the sale of their own Trills. This would result in the pooling of income across nations and the

reduction of the volatility of those nations' income streams, because different nations' business cycles are less than perfectly correlated.[6] This is an attractive prospect: if developing countries were to issue Trills and purchase developed countries' Trills, the booms and busts the developing countries experience would have a muted impact on their ability to provide basic services and to manage their own debt obligations. Emerging market economies have perhaps the most to gain from the introduction of Trills, but the prospect of a developed economy sharing in the growth of these emerging economies should be reward enough for providing this free-market-priced insurance policy.

Who Would Buy Trills?

While we expect pension funds and individual Americans would line up to purchase Trills, they may not be the only interested parties. Foreigners would also be potential purchasers. As noted in the previous section, purchases of other countries' Trills would offer a new and valuable kind of international diversification.

Should we be concerned with foreigners owning this sort of claim on America's income? We do not think so. First of all, foreigners are already allowed to own Treasury debt, so Trills set no precedent. Furthermore, if Trill-equivalents from other countries become available to Americans, the resulting exchange of claims would be of great value to American pension fund managers (and fund managers from around the world) because of the benefits of diversification. Business cycles of nations, while correlated, do not move one-for-one, and the availability of assets that perfectly track GDP cycles of nations from around the world would provide a new asset class for diversification, an important contribution of Trills.

Trills even offer the potential to stabilize world economies by increasing international interconnectivity and reducing the incentive of governments to engage in mutually destructive trade wars.

Similar Securities from Around the World

The first proposal we know of for a true GDP-linked bond came from Shiller in 1993. In *Macro Markets: Creating Institutions for Managing Society's Largest Economic*

[6] See, for instance, Backus, Kehoe and Kydland (1995) and Baxter (1995).

Risks he draws comparisons between a firm's earnings and a country's GDP, and describes the same GDP-linked security that we propose here. This study is itself based very closely on Kamstra and Shiller (2008).

Borensztein and Mauro (2004) sought to revive the case for GDP growth-linked bonds, Kruse, Meitner and Schroder (2005) detail how to price bonds with coupons tied to the growth of the GDP, and Griffith-Jones and Sharma (2006) outline the benefits of introducing GDP-linked bonds and document various countries' efforts to establish such instruments. Spilinbergo et al. (2008) argue that, to reduce the vulnerability of the economy to systemic financial crises, governments might sell recession insurance to firms and individuals, arguing that such insurance would help reduce the effect of lost confidence on reduced investment and consumption. Of course, if the government issues Trills it would have a similar impact, since individuals' tax liabilities to support payment of the government debt would be reduced in bad times.

To the best of our knowledge, true GDP shares have not yet been issued by any country. In the mid-1990s, bonds with attached GDP warrants were issued by Bulgaria, Bosnia and Costa Rica in concert with their Brady Plan restructurings. These bonds included clauses to increase coupon payments at predetermined GDP thresholds rather than in lockstep with the GDP.

In 2001, Singapore issued the New Singapore Shares, which pay a 3 percent return plus the economic growth rate of Singapore, if positive, rather than a coupon tied to the GDP *level*. Argentina's 2005 GDP warrants are a fairly complicated financial instrument. Payments are linked to the growth of the economy, rather than the level of the GDP and are conditional on three criteria being met simultaneously. First, real GDP must be at a higher level than a predetermined baseline GDP. Second, real growth of GDP must be greater than a baseline growth. Finally, there is a total payment cap.

In contrast, the Trill would be as simple and familiar as shares in corporations. We believe that transparency and simple structure are essential to establishing demand for these securities and ensuring that their market is liquid. Tying the Trill's payment to the *level* of the GDP would accomplish these goals.

While a few countries have experimented with GDP bond-like instruments, a sensible question to ask is why there has been no attempt to issue a true GDP bond. There

are several possible reasons for the limited interest to date. First, it is plausible that government Treasury officials do not perceive any need to issue such a security. The primary obligation of any country's Treasury (as it is commonly perceived) is to enable low-cost financing for government's operational needs. Treasuries are not generally perceived as having a risk-management role. Investors will typically be willing to pay a higher price for fixed-coupon debt than for GDP bonds whose coupons would fluctuate with the economy's performance. Hence, fixed-coupon debt and, especially, real-return debt will normally be relatively cheaper for the government to issue. Our own analysis indicates the cost of issuance of the Trill will be in the order of 150 basis points above short term government debt.

Another reason for Treasury's limited interest in issuing GDP bonds likely arises from the secondary objective of the government's debt policy—to ensure the efficiency of the market for government securities. To date, the government has sensibly focused its efforts on providing liquidity to the traditional nominal-coupon bond market. Without the regular and routine issue of large quantities of new nominal government debt, the market for nominal debt instruments cannot function properly. This pressure to promote government debt market liquidity has a tendency to mitigate any potential interest in exploring new debt instruments.

There is a possibility that trills could be privately issued. Index-linked bonds, called MacroShares, have been issued under the auspices of the US company MacroMarkets LLC that could be a model for the private issuance of GDP-linked securities. The securities, whose structure is patented in the United States, are issued by a special entity whose charter dictates that it does nothing else, and invests their underlying assets according to specific rules. The rules state that shares are automatically issued and redeemed upon public demand in creation units only in pairs, one long the index, the other short the index, and the assets underlying the shares are invested in U.S. Treasury bills, so that the issuer cannot fail to index effectively. The long and short securities, when issued, trade separately on a stock exchange. MacroShares indexed to the S&P/Case-Shiller 10-City Home Price Index, with the ticker symbols UMM and DMM, are now traded on the New York Stock Exchange Arca. Such a structure could be applied to the issuance of trills in the United States, by substituting U.S. GDP for real estate price in the structure. These could even be

perpetual trills, since the structure is not dependent on the activities and survival of any financial entity that does other business. The structure creates a market for both long and short interests in GDP, and the hope in establishing such a private market for GDP in the U.S. would be that a sufficient number of investors would want to take a short position in U.S. GDP. Such investors might include state governments of the U.S, who could use them to hedge their own tax and expenditure risks, or corporations whose revenues rise and fall with GDP

But, trills, by their very nature, are most naturally issued by a national government. A national government can most effectively hedge the claims provided by a GDP bond with both the right to tax income and the ability to invest proceeds from issuing the GDP bond in other nations' similar securities.

Notwithstanding their novelty and these reservations, however, we feel that Trills would be a useful addition to the range of available government securities in the U.S. Pension funds are larger than ever, and the good fit between this type of asset and their liabilities suggests to us that there would be a lively appetite for Trills, and that they would be issueable at reasonable cost to the government. Importantly, moreover, we see think that by funding currently unfunded liabilities, the federal government could issue Trills without either increasing its net indebtedness or hurting the liquidity and completeness of the markets for other government securities.

Conclusions

A Trill is essentially an equity stake in the economy. When publicly traded companies issue equity rather than debt, they typically do so because debt markets are not available to them or the addition of more debt to their capital structure would unacceptably increase their risk of bankruptcy. Given a choice, incumbent equity holders would rather not have to share with others the upside of the growth potential of a company. For the introduction of Trills to make sense for, it must be the case that the availability of an equity stake in the U.S.solves some problem that issuing debt cannot solve.

We believe this new debt instrument would be of interest for its stabilizing influence on the budget (as the Trill's coupon payments would fall with declining budget revenues), in contrast to the menu of fixed coupon debt instruments currently available.

Our valuation of the Trill indicates its yield would be very attractive to the issuer, the U.S. government, and Trills would, at the very least, provide a convenient tool to fund federal government obligations that are currently unfunded, making government finances more transparent.

We have made a case that Trills would also help pension plans diversify into inflation-protected assets tied to the wealth of the nation and would allow individuals planning for retirement to enjoy the benefits of real economic growth in the U.S. In the language of financial economists, the current menu of available assets is *incomplete*. There are risks in the economy, related specifically to human capital and the GDP that cannot be traded in existing financial markets. (The risks associated with companies' fortunes, in contrast, can be traded in existing equity and corporate bond markets.) For investors seeking a return tied to U.S. labor productivity and the overall growth in the economy, there is simply no substitute for the Trill. Introducing Trills would help complete financial markets, which would lead to better diversification and hedging possibilities for everyone.

Standard financial analysis suggests that Trills would provide the issuer, the U.S. government , with a budget-stabilizing, moderate cost debt instrument, and investors with an asset that cannot be replicated with existing assets, allowing investors new portfolio diversification strategies that preserve high returns and lower volatility. Indeed the current financial crisis can be, at least in part, tied back to a shortage of counterparty-risk-free assets and fund manager's thirst for high yield investments. The existence of a large float of Trills issued by the U.S. government could help ensure that this coincidence of factors is unlikely to ever appear again. The issuer and the investors in Trills would both stand to gain from Trills, another case of win-win through financial innovation and diversification.

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Appendix: Valuation of the Trill

Since the Trill is a security that is not now available, its price and return can be only estimated. We present two valuation exercises here, one being the projected valuation of a Trill, the other being the valuation of the market, proxied using the S&P 500 index. Analysis of a priced asset facilitates a comparison between the observed value and the estimated value. Presumably, if the valuation technique works well for pricing the S&P 500 index, we can lean on it to price the Trill.

A large variety of methods have been proposed for the valuation of equity, and these are applicable as well to Trills. The best-known methods are based on the Gordon Growth Model of constant dividend growth and constant discount rates. The Gordon Model, which discounts expected future cash flows, defines the price of an asset as equal to the next period's cash flow divided by the discount rate minus the growth rate of cash flows. For example, if the next period cash flow is expected to be $1, and the discount rate is 10 percent and the growth rate of cash flows 5 percent, then the Gordon Model would indicate a price of $20. (P=$1/(0.1-0.05)).

While the notion of constant discount rates and dividend growth rates is simple to work with, more realistic models of dividends and discount rates have been developed, including models that embed a fixed probability of maintaining the dividend payment at current levels and a probability of raising it.

One early model, based on methods developed by Campbell and Shiller (1988), was used by Shiller (1993), but that method as applied to GDP took no account of changing discount rates.

The Additive Markov Gordon model (see Equation 1 of Yao 1997) and the Geometric Markov Gordon model (see Equation 2 of Yao 1997) are more recent examples of equity valuation models. They still impose constant discount rates, meaning that investor risk aversion and market interest rates are constant, which seems improbable.

Another extension of the Gordon Model developed by Donaldson and Kamstra (1996), permits predictably changing and autocorrelated dividend growth and discount rates. This autocorrelation can be understood as a fade rate; that is, the speed at which a rate converges to its long-run stable rate. The more autocorrelation, the slower the fade and

the higher the value of the asset experiencing a (temporarily) higher-than-average growth in cash flows. We have not fully resolved our differences on the extent to which the volatility of markets can be explained in terms of a rational model, but agree that it is useful to consider such models.

To appreciate the importance of fade rates in valuation, take the example of a firm with two equally likely scenarios for cash-flow growth rates. Under one scenario, the rate decreases from its past average of 10 percent to 7 percent. Under the other, the average rate increases to 13 percent. Once changed, the average rate remains constant.

Before the change in growth rates, the expectation is for an average growth of 10 percent, as it has been before any change. If the discount rate is expected to be 15 percent and the most recent dividend was one dollar, then the classic Gordon Growth Model would yield a price of \$1/(0.15-0.10) or \$20 per share.

However, if we recognize that cash-flow growth rate changes are permanent (an extreme form of autocorrelation, with no fade back to the average), then the Gordon prices should be calculated for each scenario separately and the two prices are averaged to get a price that accounts for this autocorrelation. The low cash-flow growth rate case yields a price of \$1/(0.15-0.07) or \$12.50 per share, and the high-rate case yields a price of \$1/(0.15-0.13) or \$50.00 per share, for an average price of \$31.25. Accounting for the fade rate dramatically changes the price estimate, increasing it by more than 50 percent.

Very similar numbers result if we use discount-rate changes instead of cash-flow growth rate changes. Even more dramatic examples can be constructed if both discount rates and cash-flow growth rates move in opposite directions. While it is straightforward to adjust the Gordon Model for a simple scenario like this, the Donaldson and Kamstra (1996) technique permits extremely complex scenario analysis that is otherwise infeasible, scenarios in which the cash-flow growth rate and/or the discount rate never settle down, and possibly influence each other as well. For more detailed descriptions of all these techniques, see Kamstra (2003).

Regardless, for all of these valuation techniques we need to establish the growth rate of cash flows, the cash flows themselves and the discount rate. Discount rates are often formed as the sum of a short-term, risk-free rate and a risk premium, the approach adopted

here. The equity or risk premium is the premium investors demand before the fact, when the decision to invest in risky assets like equities instead of risk-free debt is first made.

A downward-trending equity premium also needs to be incorporated, motivated by recent work of Pástor and Stambaugh (2001). This work suggests a total drop of 80 basis points over the period considered, the last half-century, including a sudden drop of 50 basis points in the early 1990s. It is too soon to tell whether the financial crisis that began in 2007 with the subprime crisis represents a break in this trend. The literature on the equity premium is large, continuously growing and much too vast to fully cite here. For recent work, see Bansal and Yaron (2004), Graham and Harvey (2005) and Jain (2005). For excellent surveys see Kocherlakota (1996), Siegel and Thaler (1997), Mehra and Prescott (2003) and Mehra (2003).

The average dividend yield on the S&P 500 index over roughly the last half-century has been slightly more than 3 percent, though it has trended down remarkably, recently, before the subprime crisis, hovering around 2 percent. Cash-flow growth has averaged about 6 percent and has been quite variable, with dividends falling as much as 3 percent in some years and growing in excess of 15 percent in others.

Growth in dividends shows little persistence or predictability, in contrast to one-year, T-bill rates, which are highly persistent (i.e., exhibiting a very low fade rate). T-bill rates have averaged just less than 6 percent over the last half-century, from as low as almost 1 percent to more than 14 percent. Even incorporating very low-risk premia, simple Gordon Growth Models imply much lower prices for the S&P 500 index, and much higher yields than are seen in the market, so we do not employ these techniques for the pricing of Trills.

Using a risk premium that averages 3.5 percent, starting at 4 percent in the early 1960s and declining to roughly 3 percent by 2007 (as implied by Donaldson, Kamstra, and Kramer, 2007 and Graham and Harvey, 2005), incorporating a slow fade rate for discount rates and a very rapid fade for cash-flow growth rates, and using the technique of Donaldson and Kamstra (1996), we find much more reasonable prices and yields than can be produced by the Gordon Growth models. Indeed, these results closely match the actual market prices and yields. (See Figure 1, Panels A and B in the main text.)

Had the U.S. government issued Trills for the last half-century, the growth rate of the cash flow from this asset would have averaged roughly 7 percent (nominal) annually, from as low as approximately 1 percent to as high as approximately 13 percent. This annual growth rate is about half as volatile as the S&P 500 index cash-flow growth rates over the same period. As well, the growth rate of this cash flow would be strongly autocorrelated, in contrast to the cash-flow growth rates of the S&P 500 index. Again, using an average risk premium of 3.5 percent, incorporating a slow fade rate for discount rates, a slow fade rate for cash-flow growth rates and the technique of Donaldson and Kamstra (1996), we find a price appreciation of Trills from the 1960s that is very similar to that of the S&P 500 index. This growth is driven largely by two factors: the relatively high growth rate in cash flows (GDP) and the strong persistence in these growth rates. (See Figure 1, Panels C and D in the main text.)

A separate but closely related question is whether investors would hold a substantial portion of their portfolio in Trills, if Trills were available. In order to answer this question, we must compare the risk, return and covariance of the return from holding Trills with other risky assets. Consider a three-risky-asset world (the S&P 500 index, long-term government bonds and Trills), plus a risk-free asset (a one t-bill). Over the past half-century, the returns to these assets (returns to the Trill are calculated assuming a 3.5 percent risk premium and hence mechanically about 3.5 percent above the risk free return) are 12 percent, 7.3 percent, 10.7 percent and 6 percent for the risk-free asset. The volatilities of these assets are 15 percent, 12 percent, 7 percent and zero, respectively. The covariances of these assets indicate small positive correlation between the S&P 500 index and the Trill, small negative correlation between long-term bonds and the S&P 500 index and somewhat stronger negative correlation between the Trill and long-term bonds. Standard mean-variance (imposing a 1.5% risk premium for Trills, suggested by the CAPM) produces an optimal portfolio composition of 28 percent of assets in long-term bonds, 38 percent in the S&P 500 index and 34 percent in Trills.

These estimates were made using a sample period that ends in 2007, before the dramatic fall in stock prices with the subprime crisis. Future research, incorporating more stock market data, may lead to changes in this optimal portfolio composition. If, as might turn out to be the case, the new regime shows higher stock market volatility and lower

stock market average returns, the implied portfolio weights to Trills might be even higher. Perhaps some investor demand for Trills will be based on such an assumption, whether it is right or not. But to study the possibility of such a regime change, we can only wait and see as more data become available.