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A recent wave of innovation in the financial markets has raised difficult tax policy questions. Professor Strnad describes several frameworks for designing tax rules for new financial products and shows that two types of existing approaches, bifurcation and integration, can create tax systems that are universal, meaning that the system assigns a tax treatment to every transaction, and consistent, meaning that changing the form of the transaction will not affect that treatment. In particular, Professor Strnad shows that the spanning method, a particular bifurcation approach, can create a consistent and universal tax system if the system is also linear. Constraints created by the current tax system’s treatment of certain types of assets, however, prevent the spanning method from providing a practical solution to the problems posed by the taxation of new financial products. Professor Strnad also shows that integration schemes can provide universal and consistent tax systems, even if those systems are nonlinear. Still, discontinuities in the current tax law limit the ability of integration schemes to solve all of the problems created by financial innovation. As a result, Professor Strnad concludes that, in the absence of a major congressional overhaul of the tax laws, policymakers should prescribe tax rules for new financial products on a case by case basis.

INTRODUCTION

The past two decades have witnessed the advent of financial engineering as investment bankers, lawyers, and other specialists have created innovative and sometimes complex financial instruments that allow investors and issuers to hedge risks, to speculate, and to achieve desirable tax results. The monetary volume of these new instruments is staggering.1

Financial innovation poses a deep challenge for tax policy. The current United States tax system is based on a system of "tax cubbyholes," a few idealized transactions for which the system specifies an exact tax treatment. Since any given new financial product is unlikely to fit squarely into a particular cubbyhole, the appropriate tax treatment for such products is often unclear.

Tax indeterminacy of this type has fostered extensive debate and numerous proposals concerning one new financial product, contingent debt. Traditional debt consists of an obligation specifying fixed interest and principal payments. Contingent debt, on the other hand, combines fixed payments with payments that depend on uncertain future events, such as the level of a commodity price or equity index.

The proposals put forward for taxing contingent debt reflect four theoretical approaches for taxing new financial products: bifurcation, integration, local pattern taxation, and global pattern taxation. "Bifurcation" decomposes a new...
financial product into a collection of component instruments, each with a known tax treatment. The 1991 version of the Proposed Treasury Regulations for contingent debt apply this approach. Operationally, these Regulations call for dividing the instrument into a noncontingent portion and a contingent portion by subtracting the present value of the noncontingent payments from the issue price of the instrument. The noncontingent portion, consisting of fixed payments and their present value, is subject to the usual taxation rules for ordinary debt instruments. The remaining contingent part of the instrument "will have the economic characteristics of one or more options or other property rights [which] . . . can be taxed as they would be taxed if issued separately." Thus, it may be necessary to divide the contingent part itself into separate pieces, each having a known and distinct tax treatment.

"Integration," the logical complement of bifurcation, pools financial instruments together rather than splitting them apart. The resulting aggregate cash flow is taxed according to its "predominant characteristic." For example, several commentators suggest that where a taxpayer fully hedges the contingent portion of contingent debt, tax policy should combine the hedge position with the contingent debt and treat the consequent riskless cash flow as ordinary debt.

"Local pattern taxation" applies a single generic treatment to all new financial products. This generic treatment includes rules for timing, characterization, and source of cash flow. The term "local" emphasizes the fact that the generic treatment applies only to new financial products. The tax treatment of

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5. Although bifurcation suggests division into two pieces, the literature uses the word to describe the decomposition of a financial instrument into two or more pieces. I follow that convention in this article.


7. Notice of Proposed Rulemaking FI-189-84, 1991-1 C.B. 834, 835. The pertinent text of the Proposed Regulation calls for treating the contingent payments "in accordance with their economic substance as payments pursuant to one or more options or other property rights." Prop. Treas. Reg. § 1.1275-4(g)(4)(i), 56 Fed. Reg. 8308 (1991). Neither the explanation nor the text of the Proposed Regulation specify a method for choosing one particular decomposition of the contingent payments into other assets. More than one such decomposition may be possible.


9. See, e.g., Kleinbard, supra note 3, at 953; ABA Report, supra note 3, at 1199-1200. To see how hedging works, consider the following example. A company issues gold bonds that feature a payment that is tied to the price of gold on the date that the bond matures. The company also buys gold futures. Purchasing these futures in the right amount provides an exact offset against changes in liabilities on the bonds caused by fluctuations in the spot price of gold. An increase in gold prices would result in a heavier obligation under the bonds and in equal and offsetting gains on the gold futures positions. The company might engage in this type of hedging to achieve a lower cost of capital, as issuing gold bonds may be a cheap way to borrow money given inefficiencies in other segments of the capital market. This type of motivation appears to be very important in the real world. For example, the exploitation of capital market and regulatory inefficiencies is central to the classic arbitrage explanation for the growth of the multitrillion dollar market in swaps. See Hu, Regulatory Paradigm, supra note 2, at 350-53, 365.
preexisting financial instruments may deviate sharply from that generic treatment. Local pattern taxation may be combined with bifurcation and integration. For example, a recent American Bar Association report advocates bifurcating contingent debt into contingent and noncontingent portions but then taxing the contingent portion as a single unit under a set of generic rules.10

"Global pattern taxation" applies a single generic treatment to all instruments. This approach directly responds to the idea that the current variety of distinct tax treatments for different investments makes it especially difficult to prescribe tax rules for new financial products. For example, although equity investments with no current cash flows avoid taxation until realization occurs, interest is accrued and taxed on zero coupon bonds under the Original Issue Discount (OID) rules even though there is no cash flow from such bonds until maturity. When an instrument combines the features of a zero coupon bond and an equity investment that pays no dividends,11 it is unclear whether income should be accrued and taxed or deferred until realization. Global pattern taxation would obviate such dilemmas by imposing a single consistent method (such as cash flow taxation or accretion taxation) to all instruments, including new financial products.

Assessing the relative merits of these disparate approaches requires a framework by which to compare them. The development of such a framework is one of the main purposes of this article. The analysis that follows relies heavily on two distinct desiderata for a good tax system: universality and consistency. Two variants of the consistency principle, linearity and continuity, also play an important role.

Universality requires that the tax system specify a tax treatment for every possible transaction. This principle is attractive both as an administrative goal and as an ideal in a system faced with financial innovation. If the tax treatment of particular portfolios of cash flow patterns is unclear, taxpayers and the government will face heightened administrative costs. The government will need to specify rules for ambiguous situations, and, prior to the development of such

10. See ABA Report, supra note 3, at 1195-1201. The report uses a "cost recovery rule" for timing, requiring that basis be recovered before any gain is recognized. Gain would be ordinary or capital depending on whether the transaction is part of the ordinary course of business or is an investment activity. The report does not specify sourcing rules but strongly urges the development of a uniform set of such rules. Id. at 1200.

A similar example is the "expected value taxation" system suggested by Professor Reed Shuldiner. Reed Shuldiner, A General Approach to the Taxation of Financial Instruments, 71 TEX. L. REV. 243, 283-89 (1992). Under this system, one would decompose each asset into a noncontingent portion consisting of all expected cash flows and a residual contingent portion. An approach similar to the OID rules would determine the tax for the noncontingent portion, with income accruing based on the increase in present value as future expected cash flows draw near. A realization approach would apply to the residual contingent portion, with no tax until the time when risk is resolved and final cash flows materialize. Id. at 285.

11. For example, a debt instrument might consist of the right to receive $1000 plus the level of the S&P 500 index times $1 in 10 years. The $1000 payment is fixed. Without the index component, the instrument would be a zero coupon bond. But the right to receive a payment contingent on the future value of the S&P 500 index is an equity interest equivalent to buying a stock that does not pay dividends and then selling the stock at a specified future time.
rules, taxpayers will be unable to predict the tax consequences of holding particular instruments or portfolios.

Even if a tax system is universal, financial innovation poses another set of potential problems. Innovative packaging of a set of cash flows may result in a tax that differs from the tax that would be due if the cash flows were packaged in a more traditional manner. In a tax system where the same pattern of cash flows may have different tax consequences depending on the form chosen for transactions or portfolios, taxpayers will expend resources searching for the most advantageous form. At the same time, the government will be concerned that many tax treatments will become "elective" for taxpayers who can change these treatments by recasting their transactions or portfolios. Thus, even if the tax system is universal, substantial administrative costs may result if arrangements that are equivalent financially do not have the same tax consequences.

This problem motivates the idea of consistency. A tax system is consistent if and only if every cash flow pattern has a unique tax treatment. In such a system, it is not possible to manipulate tax outcomes by repackaging cash flows into different financial vehicles.12

Consistency is an important objective not only because of the administrative costs caused by its absence but also because of its close connection with "tax arbitrage." Tax arbitrage arises in its purest form when a series of transactions results in no net cash flow but provides tax advantages. Suppose, for example, that two portfolios result in the same cash flows but that one portfolio produces capital gains and losses while the second portfolio produces ordinary gains and losses. Assuming both portfolios are likely to produce gains, an investor can make money at government expense (with high probability) by matching a long position in the first portfolio with a short position in the second. The long position results in capital gain while the short position creates an equal amount of ordinary loss. The combined net cash flow from the two positions is zero. "Conversion" of ordinary income into capital gain occurs because ordinary income is offset by the ordinary loss generated by the short position and replaced by the capital gain from the long position. If the tax rate for capital gain is lower than the rate for ordinary income, the taxpayer receives a tax reduction without making any net investment.

This series of transactions violates consistency because it is equivalent, in cash flow terms, to doing nothing, and the usual result for a taxpayer who does not engage in any transactions is that there are no tax consequences. In a consistent tax system, tax arbitrage is not possible. Since tax arbitrage tends to defeat distinctions set up in the tax laws, such as the distinction between capital gain and ordinary income, and tends to produce free money at government expense for well-capitalized taxpayers, the usual presumption is that tax arbitrage is an evil to be controlled. This view provides a normative basis for

12. Even commentators who believe that the consistency goal is unattainable still see it as normatively appealing. See, e.g., Hariton, supra note 4, at 1224; Kau, supra note 3, at 1004.
requiring consistency that goes beyond the goal of reducing administrative costs by making tax treatments determinate and unmanipulable.\footnote{Tax arbitrage can serve positive social goals by inducing price changes that are socially desirable. These price changes largely or entirely offset the tax advantages of the arbitrage itself. \textit{See, e.g.,} Alan J. Auerbach, \textit{Should Interest Deductions Be Limited?}, in \textit{UNEASY COMPROMISE: PROBLEMS OF A HYBRID INCOME-CONSUMPTION TAX} 195 (Henry J. Aaron, Harvey Galper & Joseph A. Pechman eds., 1988) (noting that tax arbitrage from leveraged holdings of tax-exempt securities may lower the price of borrowing for state and local governments).}

Bifurcation approaches appear capable of promoting the goal of consistency because they impose a tax on the income from each instrument equal to the sum of the taxes on the income from the components that make up the instrument. However, commentators have been extremely skeptical about the possibility of implementing operationally coherent bifurcation approaches. There are many ways to divide an instrument into pieces with known tax treatments, and different methods of division may result in different tax treatments.\footnote{Most commentators find this characteristic to be fatal. \textit{See, e.g.,} Hariton, \textit{New Rules}, supra note 3, at 237; Kau, \textit{supra} note 3, at 1004; \textit{ABA Report}, \textit{supra} note 3, at 1194-95.}

Integration methods suffer from similar ambiguities. There is more than one way to aggregate sets of instruments into groups, and the overall tax results may depend on the particular choice of groupings. In addition, the proper way to characterize a particular aggregate of instruments may not be clear in a system replete with distinct and sometimes contradictory tax approaches.\footnote{\textit{See, e.g.,} Hariton, \textit{supra} note 4, at 1222; \textit{ABA Report}, \textit{supra} note 3, at 1195.}

Local pattern taxation also entails potential consistency problems. New financial instruments may generate cash flows arbitrarily close to those of a pre-existing instrument with a known tax treatment. Unless this tax treatment happens to correspond to the generic treatment for new financial products, instruments with nearly identical cash flows may incur very different tax liabilities.

Global pattern taxation is the only one of the four general approaches that can achieve consistency and universality without an obvious operational or conceptual flaw. But because implementation of global pattern taxation would require systemic reform, this fact is of little comfort to administrators who must craft rules in a system arrayed with different tax treatments that must be taken as given.

The problems with these four approaches have fostered significant frustration in the tax reform literature. Even prominent commentators who have developed and critiqued elaborate technical approaches have resigned themselves to relying on reform measures such as "common law development" or an ongoing dialogue between the Treasury Department and tax practitioners.\footnote{\textit{See, e.g.,} Hariton, \textit{supra} note 4, at 1224 (advocating an ongoing dialogue); Lokken, \textit{supra} note 3, at 504 (suggesting the common law approach).}
sets. The specified set of assets thus "spans" the universe of possible financial assets and is therefore called a "spanning set."

The possibility of spanning the entire economy with a fundamental set of assets raises the intriguing possibility that the tax law might simply specify the taxation of assets in the spanning set. To ascertain the tax treatment of any asset not in that set, including any new financial product, one would determine the unique decomposition of the asset into a weighted sum of spanning set assets and then add up the taxes for that weighted sum. This bifurcation approach would guarantee that the tax system is consistent and universal.

Given the apparent simplicity of this method, one might ask whether it could work in a tax system where radically different approaches govern the tax treatment of particular transactions. For example, would the approach work if some transactions are subject to accretion taxation while others are subject to cash flow taxation? If the approach did work, it might be possible to retain some or all of the "tax cubbyholes" in current law while simultaneously taxing new financial instruments in a consistent manner.

Part I examines this question by studying the "spanning method," a bifurcation approach similar to the one just outlined. Using the spanning method, it is possible to specify some cubbyhole tax treatments arbitrarily, and yet still construct a set of bifurcation rules that result in a consistent and universal tax system. However, the spanning method can succeed in achieving consistency and universality only for some configurations of cubbyholes, and only if these cubbyholes are precisely defined. Short of fundamental reform, the present cubbyhole structure in the United States tax system precludes the successful use of the method.

The main task of Part II is to develop a logical taxonomy of theoretical approaches for taxing new financial products and then to relate this taxonomy to practical approaches such as bifurcation and integration. Part II begins by probing the relationship between the spanning method and the set of all consistent and universal tax systems. The first major result is that for every consistent and universal tax system, there is an integration approach that can implement that system. In contrast, not every consistent and universal tax system reduces to the spanning method. This result highlights the fact that the categories of integration, bifurcation, and local pattern taxation are not mutually exclusive. The set of successful bifurcation and local pattern approaches is a subset of the set of successful integration methods.

Developing the taxonomy of theoretical approaches and clarifying the relationships between them requires the use of two refinements of consistency.


18. Some integration approaches also would work. In fact, whenever there is a bifurcation approach that is consistent, there is also a consistent integration approach. However, the converse is not true. See text accompanying notes 68-74 infra.
“linearity” and “continuity.”19 A tax system is linear when the tax on any transaction equals the sum of the taxes on any collection of subtransactions that comprise that transaction. Part II shows that a tax system is linear and universal if and only if it reduces to the spanning method. Thus, the spanning method is not just one particular kind of bifurcation but is the paradigmatic treatment for any linear tax system.

In nonlinear tax systems—such as the current system in the United States—the concept of continuity is important. Continuity exists when portfolios that are nearly identical have nearly identical tax outcomes. Continuity is a stronger condition than consistency but weaker than linearity. Thus, linear systems are a subset of continuous systems, which, in turn, are a subset of consistent systems. Part II shows that precisely the same goals that make consistency desirable, such as obviating problems of tax arbitrage, also make continuity desirable. In addition, because the current United States tax system has significant non-linearities, certain continuous and universal integration approaches are the strongest candidates for dealing with new financial products. Unfortunately, despite the strength of these integration approaches compared to the spanning method, none are immediately applicable to the current United States tax system. Fundamental reform would have to precede their successful application.

Part III discusses the application and tax policy implications of the framework developed in Part II. The framework transcends the new financial products area. Bifurcation and integration techniques exist in many other areas of tax law. In addition, inconsistencies, discontinuities, and nonlinearities in current law provide focal points for tax-motivated financial innovation. The existence and fundamental nature of many of these inconsistencies, discontinuities, and nonlinearities means that, without systemic reform, crafting rules for taxing new financial products requires difficult, “second best” choices. Consequently, this article adds to the skepticism in the literature about bifurcation, integration, and local pattern approaches.20 Nonetheless, the conceptual framework developed here clarifies the available approaches to taxing new financial products and may inform the ongoing debate about whether and how to institute such reform.

I. The Spanning Method

Spanning studies from the finance literature provide a starting point for discussing necessary and sufficient conditions for tax systems to be consistent and universal. The spanning literature ranges from straightforward early work by

19. Consistency, continuity, linearity, and universality are ideals of operational coherence for the tax system. However, this set of ideals is not comprehensive. There may be situations where it is desirable to sacrifice operational coherence for other goals such as economic efficiency or distributional equity.

Nonetheless, because coherence is a significant concern for both taxpayers and administrators, the tax structure implications of different operational coherence norms are important. Moreover, knowledge of the circumstances under which these norms are not fully attainable is valuable for courts, administrators, and legislatures, who must balance competing goals in designing and implementing tax rules.

20. See notes 14-15 supra and accompanying text.
Professor Stephen Ross\textsuperscript{21} to recent advanced mathematical analysis.\textsuperscript{22} As mentioned above,\textsuperscript{23} the spanning approach views any financial instrument as reducible to a combination of assets from a specified collection called the spanning set. Under the spanning method, the tax on the income from an instrument is set equal to the sum of the taxes on the income from the spanning set assets that comprise the instrument.

In order to clarify the results from the spanning literature and to apply them to the taxation of new financial products, this Part proceeds in four sections. First, section A illustrates the spanning method by developing a simple example consisting of an economy with three financial assets. Section B employs this example to show that the spanning method can be used to construct a consistent and universal system even under the constraint that particular existing assets must be taxed in radically different ways. Section C shows that, despite this positive result, consistency becomes unattainable when the system is over-constrained—that is, when the system has too many assets with predetermined tax treatments. In addition, even when the tax system can accommodate a particular set of disparate tax treatments, consistency may require a considerable sacrifice in terms of “tax aesthetics.” The treatment of some transactions will conflict with most major conceptions of how such transactions should be taxed. Finally, section D provides some policy perspectives on these problems, arguing that implementation of the spanning method remains infeasible absent fundamental reform of the current system.

A. Spanning in a Simple Economy

Consider an economy that lasts only two 1-year periods.\textsuperscript{24} Within this economy there are three financial assets. Two of the assets are zero coupon bonds. One bond initially costs $100 (at “time zero”) and yields $110 at the end of year one. The other bond costs $100 at time zero and yields $121 at the end of year two. Thus, interest rates are 10 percent per year for both years in the model.

The final asset is a “stock,” representing the right to collect a particular cash flow at the end of year two. The amount of the cash flow is uncertain but will take one of five possible values: $121, $242, $363, $484, or $605. Each of the five outcomes is equally likely, and no further information is available about the likelihood of any outcome until the end of the two years. Consequently, the stock’s expected final value is $363.\textsuperscript{25} Assuming that investors are risk neu-

\textsuperscript{21} See Ross, \textit{supra} note 17.
\textsuperscript{22} See Brown et al., \textit{supra} note 17; Brown & Ross, \textit{supra} note 17.
\textsuperscript{23} See text accompanying note 17 supra.
\textsuperscript{24} Two periods are the minimum needed to distinguish between cash flow and accretion treatment. The difference is that cash flow treatment allows deferral of the tax on gains until realization. Consequently, if there is only a single period in which all cash flows occur, accretion and cash flow taxation will be identical.
\textsuperscript{25} $363 is simply the average final value of the stock. Each of the five outcomes occurs with a probability of one-fifth, so that the average is $363 = ((121+242+363+484+605)/5).
this $363 has a present value of $300 at time zero, which is therefore the price of the stock at that time. Furthermore, the stock will appreciate to $330 at the end of the first year.

Finally, it is also convenient to assume that the five stock outcomes correspond to the five possible "states of the world." In other words, only five future environments are possible, and any "risky" endeavor is risky only because its outcome differs depending on which environment emerges.

Attaining a consistent and universal tax system using the spanning method requires the construction (or existence) of assets that "complete the market." In economics terminology, a securities market is complete if, for each state of the world, there is a portfolio that yields a positive amount in that state and zero in all others. Each such portfolio provides insurance against a particular state occurring. When portfolios consist solely of combinations of the stock and the two bonds, it is impossible to construct an insurance portfolio for each state. Indeed, the only asset with varying returns is the stock, and it has positive returns in all five states. Completing the market, if it is possible at all, requires the creation of additional assets.

A central conclusion of the spanning literature is that completing the market is possible if and only if there is some asset or portfolio that has distinct returns in each potential state of the world. In that case, the ability to create call

26. The assumption that investors are risk averse does not materially affect any of the results that follow. The results depend only on the ability to replicate any possible cash flow pattern with some combination of assets from a spanning set. This ability is a function of the set of assets available, not of the degree of risk aversion of the populace.

27. Since investors are risk neutral, they will use the riskless rate of 10% to discount expected cash flows to present value. Each risky asset will increase at a 10% rate until the end of year two, when uncertainty about the risky outcomes in the economy is resolved. Thus, during the first year the stock's price will increase by $30 over its initial value of $300.

28. The existence of complete markets simplifies the task of designing a tax system that is consistent and universal because the spanning method only works if markets are complete or can be made complete. The spanning method is important since, as Part II shows, a broad class of other approaches that guarantee consistency and universality reduce to that method. See text accompanying notes 69-77 infra. However, the existence of complete markets is not a sufficient condition for consistency and universality. These properties can only be jointly present if the tax system has a certain degree of coherence. This article shows that, absent comprehensive reform, the current tax system lacks that degree of coherence.

If all states are insurable, it is easy to see why markets are called complete: An individual can protect against any contingency that might occur. Since the ability to pass risks on to those most willing to bear them is an important economic mission for capital markets, completeness is a desirable property.

30. Professor Ross proved this result in a 2-period world with a finite number of states similar to the one postulated here. See Ross, supra note 17, at 84-86. Others have since proven similar results using models with a continuum of states of the world and multiple periods. See Brown & Ross, supra note 17 (continuum of states); François R. Velde, Essays in the Theory and History of Optimal Fiscal Policy, 66-70 (1992) (unpublished Ph.D. dissertation, Stanford University, on file with the Stanford Law
options on that asset or portfolio ensures a complete market. A call option consists of the right, but not the obligation, to buy a particular asset at a prespecified price, known as "exercise price" or "strike price."\textsuperscript{31}

The basic idea behind this complete market result is simple: By creating call options, it is possible to divide an asset with distinct returns in every state (such as the stock in this case) into a series of insurance portfolios that yield a positive return in one state and zero in all other states.\textsuperscript{32} This series of insurance assets is a "spanning set" since any portfolio or asset is equivalent to a unique combination of insurance assets.

Working out an example based on the 5-state economy described above helps to demonstrate this method of completing the market. As a first step, it is convenient to label the states by reference to the stock returns:

<table>
<thead>
<tr>
<th>Table I: States and Stock Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>State</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>A</td>
</tr>
<tr>
<td>B</td>
</tr>
<tr>
<td>C</td>
</tr>
<tr>
<td>D</td>
</tr>
<tr>
<td>E</td>
</tr>
</tbody>
</table>

Next, consider call options on the stock that the holder can only exercise when they expire at the end of year two.\textsuperscript{33} The value of each such call option at that time will be equal to the difference between the price of the underlying stock and the contractually specified strike price, if that difference is positive. Otherwise, the option will be worthless.\textsuperscript{34}

\textsuperscript{31} An option is a contract between two parties. The buyer (also called the holder) of a call option has the right to buy a particular asset, such as a stock, at a particular price specified in the contract. The seller (also called the writer) of the call option agrees to sell the specified asset at the specified price to the holder of the option if the holder exercises the option.

\textsuperscript{32} Alternatively, one can ensure complete markets by using only puts on the asset or portfolio. See Ross, supra note 17, at 82. A put consists of the right to sell an asset at a particular price. Both puts and calls are necessary to complete a market in cases where the exercise prices of all options are restricted to be positive. Id. at 84.

\textsuperscript{33} Call options that can only be exercised on the expiration date are called "European" call options. In contrast, the holder of an "American" call option can exercise the option at any time between the date the option is written and the expiration date. European options suffice in the example developed here because all risk in the economy is resolved at the end of year two. Options exercisable only at that time will account for all the possible risky outcomes.

\textsuperscript{34} Suppose that the strike price of a European call option is $X$. If the price of the stock is $(X+Y)$ at the time of expiration and $Y$ is greater than zero, then the option holder will exercise the option since the option will be worth $Y$ at the time of expiration. Conversely, if $Y$ is negative at the time of expiration (meaning that the stock price is below $X$), then the holder will not exercise the option. In that case, the option is worthless and expires. For a more in-depth introduction to options,
From this set of call options, one can create insurance portfolios that yield positive returns in one state but zero in all other states. This task is easy for state E. A call option on the stock with an exercise price of $484 will be worth $121 if state E occurs and zero if any other state occurs.35

Creating insurance portfolios for states A, B, C, and D requires combining call options with differing strike prices. For convenience, denote a call option with a strike price of $X as C(X) and denote the stock as S. The following table shows various options and their payoffs in each state:

**TABLE II: OPTION PAYOFFS IN VARIOUS STATES**

<table>
<thead>
<tr>
<th>State</th>
<th>C(484)</th>
<th>C(363)</th>
<th>C(242)</th>
<th>C(121)</th>
<th>S = C(0)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$121</td>
</tr>
<tr>
<td>B</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$121</td>
<td>$242</td>
</tr>
<tr>
<td>C</td>
<td>$0</td>
<td>$0</td>
<td>$121</td>
<td>$242</td>
<td>$363</td>
</tr>
<tr>
<td>D</td>
<td>$0</td>
<td>$121</td>
<td>$242</td>
<td>$363</td>
<td>$484</td>
</tr>
<tr>
<td>E</td>
<td>$121</td>
<td>$242</td>
<td>$363</td>
<td>$484</td>
<td>$605</td>
</tr>
</tbody>
</table>

As indicated in the table, the stock is equivalent to an option with an exercise price of zero. Denoting an insurance portfolio that yields $1 in state Z and nothing in any other state as P(Z), the following equations represent the combinations of the stock and call options on the stock that generate an insurance portfolio for each state:36

\[
P(A) = \left(\frac{1}{121}\right) \times \left[S - (2 \times C(121)) + C(242)\right] \\
P(B) = \left(\frac{1}{121}\right) \times \left[C(121) - (2 \times C(242)) + C(363)\right] \\
P(C) = \left(\frac{1}{121}\right) \times \left[C(242) - (2 \times C(363)) + C(484)\right]
\]

35. This option gives the holder the right to buy the stock for $484 at the end of year two. If states A, B, C, or D occur, the holder will not exercise the option since the stock will be worth at most $484. However, if state E occurs, the price of the stock will be $605, and the option will be worth $121 ($605-$484). Actually, any call option with an exercise price that is greater than or equal to $484 but less than $605 would suffice for insuring state E. An exercise price of $484 merely aids in the exposition of the example.

36. It is easy to verify these relations. For example, to verify the relation for P(B), consider the following table of payoffs:

**TABLE OF PAyOFFS**

<table>
<thead>
<tr>
<th>State</th>
<th>C(121)</th>
<th>-2 x C(242)</th>
<th>C(363)</th>
<th>Aggregate Payoff</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$0</td>
<td>0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>B</td>
<td>$121</td>
<td>0</td>
<td>$0</td>
<td>$121</td>
</tr>
<tr>
<td>C</td>
<td>$242</td>
<td>-$242</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>D</td>
<td>$363</td>
<td>-$484</td>
<td>$121</td>
<td>$0</td>
</tr>
<tr>
<td>E</td>
<td>$484</td>
<td>-$726</td>
<td>$242</td>
<td>$0</td>
</tr>
</tbody>
</table>

As the table indicates, combining one long position in each of C(121) and C(363) with two short positions in C(242) results in a portfolio that pays $121 in state B and zero in all other states. Dividing this portfolio by 121 yields P(B), paying $1 in state B and nothing in any other state.
P(D) = (1/121) x [C(363) - (2 x C(484))]
P(E) = (1/121) x [C(484)]

Negative signs in front of call options denote the sale, rather than the purchase, of those options. Hence, appropriate long and short combinations of the stock and the five specified call options on the stock create insurance portfolios for each possible state. As a result, creation of the options completes the market in this example.

One can fully describe any asset with payoffs at the end of year two simply by specifying its payoffs in each of the five states. Therefore, any such asset is a combination of the five portfolios in the set [P(A), P(B), P(C), P(D), P(E)]. For example, consider an asset that pays $2 in state B, $5 in state D, and nothing in the other three states. This asset is equivalent to a portfolio consisting of two P(B)s and five P(D)s. Moreover, because the P(Z)s represent combinations of C(X)s, one can also describe the asset as a combination of the five underlying options in the set [C(0), C(121), C(242), C(363), C(484)]. Thus, any asset with payoffs at the end of year two is equivalent to some combination of these five basic options.

It is also true that any asset from either the set [P(A), P(B), P(C), P(D), P(E)] or the set [C(0), C(121), C(242), C(363), C(484)] will replicate the 1-year payoff of any other asset or portfolio in the economy. In the model, all economic risk is resolved at the end of year two. Since investors are risk neutral, the value of all assets in the economy, including the stock, the bonds, and the options, will increase at the riskless rate of 10 percent per year during the first year. Thus, any of the assets in the two sets will replicate the returns on the zero coupon bond which pays $110 at the end of year one on an initial investment of $100.

Because each of the sets [P(A), P(B), P(C), P(D), P(E)] and [C(0), C(121), C(242), C(363), C(484)] can be used to replicate any financial asset in the economy, each is a spanning set. As such, each is potentially useful for constructing a universal and consistent tax system. However, to ensure that the system specifies a unique tax outcome for each instrument, the spanning set cannot be "overspecified." In particular, it must be impossible to remove an element from the set and still have a spanning set consisting of the remaining elements.\footnote{If it were possible to remove an asset from a spanning set and still have a spanning set, then that redundant asset would be equivalent to a linear combination of assets in the reduced spanning set. One could substitute this combination of assets for the redundant asset in any combination from the original spanning set used to represent a financial instrument. Thus, there would be two different representations for any such instrument from that spanning set. The tax treatment of the instrument would be ambiguous unless the redundant asset had exactly the same tax consequences as the equivalent combination from the reduced spanning set. One may assign tax treatments arbitrarily to the assets in a minimal spanning set and not worry about the tax system becoming inconsistent. That freedom vanishes when the spanning set is not minimal.} A spanning set with this property of irreducibility is called a "minimal" spanning set.

In fact, both of the above sets are irreducible. Irreducibility is obvious for the set [P(A), P(B), P(C), P(D), P(E)]. Each of the assets represents a 2-year return of $1 in one of the five states of the world and zero in all of the other
states. Removing any one asset from this set makes it impossible to replicate a nonzero return in one of the five states at the end of year two. Slightly more complex reasoning establishes the irreducibility of the set \([C(0), C(121), C(242), C(363), C(484)]\).38

It is no coincidence that each of the two minimal spanning sets defined above contains five assets. The model assumes that five states of the world are possible at the end of year two. At least five distinct assets are necessary to capture the distinct outcomes in these five states.39

Given the concepts just developed, it is possible to state two principles that are useful for designing a tax system capable of dealing with new financial products:

**Unique Representation Principle**: In an economy with a minimal spanning set, any collection of cash flows has a unique representation as a combination of assets in that set.

**Nonunique Minimal Spanning Set Principle**: If a minimal spanning set exists, it generally is not unique.

38. The argument works as follows: For the set \([C(0), C(121), C(242), C(363), C(484)]\) to be minimal, each element must be essential for spanning to occur. Refer to the returns in Table II, and consider first the problem of creating an asset that pays off only in state A. For this task, \(C(0)\) is clearly essential since it is the only asset with a nonzero return in state A. The next step is to show that \(C(0)\) may be combined with other assets so that the combination yields zero return in state B without also yielding zero in state A. The only asset in the set that will accomplish this task is \(C(121)\) since it is the only asset beside \(C(0)\) that has a nonzero return in state B. The combination \(C(0) - (2 \times C(121))\) yields a positive return in state A and a zero return in state B. However, this portfolio has negative returns in states C, D, and E. Thus, one must add at least one asset that makes the return in these three states zero while retaining the zero payoff in state B and a positive payoff in state A. The asset \(C(242)\) is essential for this task since it is the only asset besides \(C(0)\) and \(C(121)\) that has a nonzero return in state C. It turns out that \(C(0), C(121),\) and \(C(242)\) suffice to produce an asset with a nonzero return in state A and zero returns in all other states.

To see that the remaining two assets, \(C(363)\) and \(C(484)\), are essential elements of the minimal set, consider designing a portfolio that pays off only in state C. Asset \(C(0)\) is the only asset with a nonzero return in state A. Since any portfolio including asset \(C(0)\) would yield a nonzero return in state A, \(C(0)\) cannot be one of the building blocks for the desired portfolio. Given that \(C(0)\) is ineligible, \(C(121)\) is also ineligible because it is the only other asset with returns in state B.

The remaining three assets, \(C(242), C(363),\) and \(C(484)\) are all necessary for creating a portfolio with returns only in state C for the same reasons that \(C(0),\) \(C(121),\) and \(C(242)\) were necessary to produce a portfolio with payoffs only in state A. In particular, \(C(242)\) is necessary because it is the only remaining asset (after excluding \(C(0)\) and \(C(121)\)) that has nonzero returns in state C. In addition, \(C(363)\) is necessary to cancel out the returns from \(C(242)\) in state D, and \(C(484)\) is necessary to cancel the returns in state E from \(C(242)\) and \(C(363)\).

39. Readers familiar with linear algebra will realize that the minimal spanning set in the example must have five elements. Because there are five states of the world, the returns in the second period form a five-dimensional vector space, with the return in each state representing one dimension. The returns from the assets in the set \([P(A), P(B), P(C), P(D), P(E)]\) constitute an orthonormal basis for this vector space since each asset in that set returns $1 in one distinct state and $0 in the other four states. Any other basis, i.e., any other irreducible set of asset returns that spans the space, must also contain five elements. Furthermore, the assets in any such basis must be an invertible linear transformation of the assets in \([P(A), P(B), P(C), P(D), P(E)]\). As a result, the argument in note 38 supra that the set \([C(0), C(121), C(242), C(363), C(484)]\) is a minimal spanning set reduces to showing that the returns from this set are an invertible linear transformation of the returns generated by the assets in the set \([P(A), P(B), P(C), P(D), P(E)]\). For a general discussion of the relationship between vector spaces, bases, and spanning, see KENNETH HOFFMAN & RAY KUNZE, LINEAR ALGEBRA 28-66 (2d ed. 1971).
Rigorously establishing the Unique Representation Principle requires some linear algebra, but the intuition behind the linear algebra is easy to understand. If there were two different combinations of assets from the minimal spanning set that generated the same cash flows, then subtracting the first combination from the second would yield a new combination with zero net cash flow. This new combination would include at least one asset with nonzero weight since the first and second combinations are different by assumption. Consequently, one of the assets in the minimal spanning set would have to be a combination of other assets in that set. This relationship contradicts the assumption that the spanning set is minimal. If combining certain assets in the set replicates the returns of another asset in the set, then that asset must be extraneous. A spanning set is minimal only if it has no extraneous assets.

The above 5-state economy example illustrates the Nonunique Minimal Spanning Set Principle. There were at least two minimal spanning sets for the economy in that example. More generally, it is possible to show that there are an infinite number of possible minimal spanning sets in any economy where there is more than one distinct asset. This result follows from the fact that there are many ways to recombine assets from one particular spanning set to generate another such set.

B. A Possibility Result: Using the Spanning Method to Create a Consistent and Universal Tax System

The two principles derived in the previous section suggest that the spanning method may be used to design a consistent and universal tax system. This method consists of three steps. First, choose a particular minimal spanning set.

40. For example, suppose that the minimal spanning set is \([x, y, z]\) and that the following two combinations result in the same cash flow:

\[
\begin{align*}
3x + 5y + 2z \\
2x + 3y + 7z
\end{align*}
\]

Subtracting the second combination from the first yields:

\[
x + 2y - 5z
\]

This third combination results in zero net cash flow since it is the difference of two combinations yielding identical cash flows. As a result, it must be true that

\[
x = 5z - 2y
\]

In other words, holding asset \(x\) is equivalent to simultaneously holding a long position in five units of \(z\) and a short position in two units of \(y\), and any portfolio formed from a combination of \(x, y,\) and \(z\) can be formed from a combination of \(y\) and \(z\) alone.

41. For instance, in the 5-state example above, one could arbitrarily add any positive amount, \(\alpha\), of \(C(0)\) to each of the assets \(C(121), C(242), C(363),\) and \(C(484)\) in the minimal spanning set \([C(0), C(121), C(242), C(363), C(484)]\) and still have a minimal spanning set. The new set \([C(0), C(121) + \alpha C(0), C(242) + \alpha C(0), C(363) + \alpha C(0), C(484) + \alpha C(0)]\) transforms into the set of insurance portfolios, \([P(A), P(B), P(C), P(D), P(E)]\), by first subtracting \(\alpha C(0)\) from the last four assets and then applying the transformation from \([C(0), C(121), C(242), C(363), C(484)]\) to \([P(A), P(B), P(C), P(D), P(E)]\) given above. See text accompanying note 36 supra. There are an infinite number of positive numbers \(\alpha\), and each choice of \(\alpha\) yields a different minimal spanning set. Therefore, there are an infinite number of such sets.

A more rigorous demonstration that there are an infinite number of minimal spanning sets follows from the fact that any set of assets generating returns that are an invertible linear transformation of the returns from the assets in the set \([P(A), P(B), P(C), P(D), P(E)]\) is itself a minimal spanning set. See note 39 supra. There are an infinite number of such transformations as long as the dimension of the return space is at least one. In the example, the dimension of the return space is five.
second, specify the tax treatment for each asset in that set and a rule for determining the tax treatment for any possible combination of such assets; and third, impose the rule that the tax due on cash flows from any asset not in the minimal spanning set is the tax that would be due on the unique combination of minimal spanning set elements that generates the same cash flow pattern as the asset.42

The Unique Representation Principle states that for any given minimal spanning set and any given attainable pattern of cash flows, there is a unique combination of assets in the chosen minimal spanning set that will generate the specified cash flow pattern. This principle guarantees that a tax system generated by the spanning method will be consistent and universal. It will be consistent because the equivalent spanning set combination for any asset (or cash flow pattern) is unique, and each spanning set combination has a known tax treatment. It will be universal because any asset (and thus any attainable cash flow pattern) is equivalent to some combination of minimal spanning set assets.

The spanning method begins with the choice of a single minimal spanning set for implementing the method. A choice is necessary because the Nonunique Minimal Spanning Set Principle indicates that more than one minimal spanning set exists. One could design a consistent and universal tax system that applies a different minimal spanning set to different asset groups. However, choosing a single minimal spanning set makes it unnecessary either to determine which minimal spanning set applies to any given cash flow pattern or to check for inconsistencies caused by applying multiple minimal spanning sets to sets of assets generating the same cash flow pattern.43

Applying the spanning method in practice requires more detailed specification of the tax rules than simply setting out the three steps above. Of particular importance is the need to choose a method for determining the tax treatment of combinations of minimal spanning set elements. One simple choice is a “linear” rule: The tax on a weighted sum of minimal spanning set assets is the weighted sum of the taxes on the assets using the same numerical weights. Thus, if stocks x and y are in the minimal spanning set, the tax on the combination of five shares of stock x and two shares of stock y will be five times the tax on a share of stock x plus two times the tax on a share of stock y. One might distinguish the spanning method that uses this linear rule by calling it the “linear variant” of the spanning method. Because this article only considers this linear variant, however, this terminology is unnecessary.44

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42. The second step in the spanning method, specifying the tax treatment for each asset in the minimal spanning set, is similar to the cubbyhole approach under current law that specifies the tax treatment for certain familiar transactions. However, the spanning method also provides a determinate way of deciding how to tax an asset that does not have a specified treatment because it is not in the minimal spanning set. Under current law, there is no such determinate method for assets that do not fall into any existing cubbyhole. As a result, judges and administrators have difficulty dealing with new financial products.

43. There are potential benefits from using more than one minimal spanning set. Some cash flow patterns may be easier to decompose (into spanning set assets) using one minimal spanning set while other cash flow patterns may be easier to decompose using a different minimal spanning set.

44. Clearly, it is possible to employ nonlinear rules for computing the taxes on combinations of minimal spanning set elements. The linear rule is particularly interesting because of the strong connection, described below, between the linear variant of the spanning method and bifurcation approaches.
below, the term "spanning method" shall mean the linear variant of the spanning method rather than the more general class of all possible spanning methods.45

To illustrate the application of the spanning method, consider once again the 5-state example delineated above. Suppose that the minimal spanning set chosen to apply the method is the set \([C(0), C(121), C(242), C(363), C(484)]\). Suppose also that someone invents a new financial asset called "D-insurance" that provides insurance against state D occurring. One share of D-insurance yields $121 in state D at the end of year two but yields $0 if any of the other states (A, B, C, or E) occur.

Having chosen the minimal spanning set, the next step is to specify the tax treatment of each of the five assets in that set. Suppose that the tax code calls for taxing these assets on a cash flow basis, but at unequal rates: 40 percent for \(C(0), C(121), C(242),\) and \(C(363)\), but 20 percent for \(C(484)\). Conceptually, this pattern is tantamount to permitting a favorable capital gain rate on the \(C(484)\) asset while taxing the remaining assets at a higher, ordinary income rate.

D-insurance is equivalent to 121 units of the asset denoted \(P(D)\) above.46 The unique decomposition of \(P(D)\) in terms of minimal spanning set assets is:

\[ P(D) = \frac{1}{121} \times [C(363) - (2 \times C(484))] \]

The unique decomposition of D-insurance is therefore:

\[ D\text{-insurance} = C(363) - (2 \times C(484)) \]

Thus, under the spanning method, the tax on D-insurance is equivalent to the tax on one long position in \(C(363)\) plus the tax on two short positions in \(C(484)\). Applying the appropriate rates, the taxes faced by an owner of D-insurance at the end of year two in the various states are as follows:

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45. This distinction is important because some of the results below concerning "the spanning method" are only true when the linear rule applies for computing the tax due on a combination of minimal spanning set elements. See, e.g., text accompanying notes 69-70 infra, note 70 infra.

46. See text accompanying note 36 supra.
This analysis yields one peculiar result: In state E, owners of D-insurance pay a tax of $48.40 even though D-insurance returns nothing in that state. This anomaly exists because the tax system applies different rates to cash flows from C(363) and C(484). Recall that the tax system treats D-insurance as if it were a portfolio of these two assets. Thus, when state E occurs, the $96.80 tax on the gain from the long position in C(363) exceeds the $48.40 deduction on the capital loss from the two short positions in C(484).

Thus far, the analysis has had an optimistic tenor. If the government can identify a minimal spanning set, it can fashion a tax system that is consistent and universal. This "possibility result" holds true regardless of how the government specifies the tax treatment for assets in the minimal spanning set. The treatment of different assets may be conceptually distinct.

Nonetheless, the positive tax on a zero net cash flow outcome for state E in the 5-state example is disturbing. This result violates the obvious precept that when there is no income or net cash flow, an investor should not pay any tax. The cause of the result is the dissimilar treatment of certain assets: The system applies a more favorable tax rate to C(484) than to other assets. Equalizing the applicable rates on all assets would eliminate the problem. However, disparities such as a special tax rate for C(484) may have countervailing theoretical or economic justifications. Although the spanning method allows the tax system

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47. One cannot justify this $48.40 tax on a zero net cash flow as an offset for some tax benefit resulting from the purchase of the D-insurance. To demonstrate this, recall that D-insurance is equivalent to one long position in C(363) combined with two short positions in C(484). Assuming that investors are risk neutral and that the interest rate is 10%, one can calculate the prices of each option. A C(363) option pays $121 in state D and $242 in state E and nothing in any other state. The $121 and $242 cash flows have present values of $100 and $200 ($121/(1.10)^2 and $242/(1.10)^2, respectively). Given that states D and E each have a one-fifth chance of occurring, a risk-neutral investor would compute the present value of C(363) as the sum of one-fifth of $100 and one-fifth of $200, for a total of $60. Thus, the market price of C(363) must equal this $60 present value. A similar computation yields $20 as the price of C(484). As a result, the pretax price of D-insurance at time 0 is $20, the $60 cost of buying one unit of C(363) less two times the $20 revenue from writing a C(484) option.

What are the possible tax benefits associated with purchasing D-insurance? The example in the text presumes a cash flow tax system. In such a system, there is a deduction for net investment. At a 40% tax rate, the tax benefit for the $20 net investment would be 8. This would increase to $16 under an approach that considers the components of D-insurance separately. The holder would deduct the $60 cost of the C(363) using a 40% rate and would pay a tax at the special 20% rate that applies to C(484) on the receipt of the $40 from writing two C(484) options. In contrast to the possible initial tax benefit of 8 or 16, the tax at the end of year two is $48.40, and the present value of this tax as of the time of the initial benefit is 40. The resulting net tax, with a present value of 24 to 32, is totally inappropriate (under conventional tax reasoning) given that the pretax net result for the investor is a loss equal to the entire initial investment of 20.
to remain consistent and universal in the face of some desired disparities, there is a potential cost in terms of "tax aesthetics" since the tax treatment of some transactions will not make sense under standard tax concepts.

In actuality, tax systems often contain disparities, and the United States tax system is no exception. An accretion tax applies to some assets while other assets are taxed only upon realization of gains or losses. Corporate assets are subject to an extra layer of taxation. Different rates apply to income from capital and ordinary assets. The loss carryover rules create an asymmetry between the taxes of losses and gains. The next section analyzes how these disparities affect the ability to create a consistent and universal tax system using the spanning method. Unfortunately, some of these disparities cause "impossibility results" to replace the possibility result developed above. This consequence goes far beyond the problem that attaining consistency and universality using the spanning method may require a sacrifice of tax aesthetics.

C. Some Impossibility Results: Limits on the Spanning Method

Any proposal for taxing new financial products faces the real world constraint that numerous assets in the economy have a predetermined tax treatment—that is, a treatment that a policymaker must take as given in devising rules. Predetermined treatments are especially troubling when they are based on differing principles (e.g., accretion versus realization). When determining the tax treatment of new financial products, these predetermined treatments preclude the Treasury Department and the courts from implementing a global taxation approach. As a result, comprehensive reform to achieve a single global pattern for the taxation of all assets cannot be accomplished through regulations or court decisions.

The effects of constraints created by predetermined tax treatments are evident in the 5-state example from the previous section. In that example, the available assets were two zero coupon bonds and a stock. Under current United States tax law, the bonds, like other zero coupon bonds, would be subject to OID rules that have an accretion aspect. The rules impute a stream of interest payments to the bond and impose a tax on these payments even though the payments are fictional.48 On the other hand, current law generally does not impose a tax on the returns from stock until the returns are realized as either distributions or as capital gains upon sale. Thus, the stock in the example would not be taxed until the distribution at the end of year two.

The preordained tax treatments of bonds and stocks constrain the choice of tax treatments for the five assets in the particular minimal spanning set chosen

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48. Pure accretion treatment would require taxing the total change in value of the bond each year rather than merely the interest component estimated under the OID rules. These two approaches differ because the total change in value of a bond during each year may differ from the amount of interest imputed to the bond based on the initial fixed schedule of payments. For example, if interest rates increase during the life of the bond, the capital value of the bond will decline so that the total gain in some years will be less than the amount of interest imputed to the bond. Nonetheless, the OID rules are a step toward pure accretion treatment. One can view the OID component as an estimate of the annual change in value of the bond, and this estimated increase is taxed even though it is unrealized.
for applying the spanning method. To fit into the overall tax scheme, the tax on combinations of these assets that correspond to bonds and stocks must correspond to the predetermined rules.

Suppose that the minimal spanning set chosen for applying the spanning method is \([C(0), C(121), C(242), C(363), C(484)]\). This set is a particularly instructive choice because all of the assets in the set are call options, instruments that have a specific tax treatment under current law. For now, however, assume that the tax treatment of these instruments need not be the same as under current law.

The stock in the hypothetical economy is simply the asset \(C(0)\), which is already an element of the minimal spanning set.\(^4\) The initial value of the stock is $300, and there is no dividend or other realization event until the end of year two. At the end of year two, the shareholder receives a cash distribution (representing the total return on the stock) in exchange for each share. Thus, there is no tax at the end of year one, but the cash distribution net of the $300 cost per share is taxable income at the end of year two.

The 2-year zero coupon bond appreciates from $100 to $110 during year one and then from $110 to $121 during year two. Under current law, this appreciation results in OID income of $10 at the end of year one and $11 at the end of year two. Assuming a 40 percent tax rate, the bondholder will pay taxes of $4 and $4.40 at the end of years one and two, respectively.

None of the five assets in the minimal spanning set \([C(0), C(121), C(242), C(363), C(484)]\) corresponds exactly to the 2-year zero coupon bond. However, the bond is a simple combination of two of the assets in that set, one of which is the stock. Denoting the bond \(B(2)\) and the stock \(S\), the following identity applies:

\[ B(2) = C(0) - C(121) = S - C(121). \]

Because the tax treatments of both the stock and the 2-year zero coupon bond are predetermined, this equation implicitly specifies a tax treatment for \(C(121)\). The tax on \(C(121)\) must equal the tax on a position that is long one share of the stock and short one bond:\(^5\)

\[ C(121) = S - B(2). \]

A party holding \(C(121)\) would deduct the $10 imputed interest on the bond at the end of year one, resulting in a $4 tax benefit at a 40 percent rate. At the end

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4. A call option with a zero exercise price on a limited liability asset (such as the stock) is monetarily equivalent to the asset. This equivalency exists because limited liability implies that the lowest possible payoff is zero, and a call option with a zero exercise price is the right to receive any return above zero.

5. This equation is the put-call parity equation where the put has zero value. The general form of the put-call parity equation is:

\[ S + P = C + PV(X) \]

where \(S\) is an underlying asset, \(C\) is a call on \(S\) at exercise price \(X\), \(P\) is a put on \(S\) at exercise price \(X\), and \(PV(X)\) is the discounted present value of \(X\), calculated using the time until expiration and a riskless discount rate. No put term appears in the equation in the text since the exercise price is $121, the lowest possible outcome for the stock. A put will only be valuable if there is a possibility that the value of the underlying asset will fall below the exercise price. The bond ensures a return of $121 at the end of year two. As a result, the present value of the bond is the present value of the $121 exercise price.
of year two, the holder would deduct $11 for that year’s imputed interest on the bond.51 In addition, the cash distribution paid in exchange for the stock at the end of year two would trigger a tax.

Because the tax treatments of the bond and the stock are predetermined, the policymaker no longer has the freedom to choose the tax treatment of C(0) and C(121), two of the five assets in the minimal spanning set. However, complete freedom to choose the tax treatment of the other three assets remains.

Conveniently, the treatment of these three remaining assets can be chosen to create a generic treatment for call options. In particular, the government could tax each call option as if it were equivalent to holding the underlying asset and borrowing an amount equal to the difference between that asset’s value and the cost of the option at the time of purchase.52 This generic rule is consistent with the predetermined treatments for C(0) and C(121) under current law. These treatments impute no borrowing for C(0), the stock, and $100 of borrowing for C(121). The appropriate amount of imputed borrowing for C(0) under the generic rule is also zero. C(121) has an initial value of $200 com-

51. Under current law, corporate issuers may deduct the imputed interest payments on zero coupon bonds. See I.R.C. § 163(e) (1988). However, it is unclear whether a deduction for imputed interest is available if a nonissuing entity (such as an individual investor) sells a zero coupon bond short.

Selling short involves borrowing the security that is sold. Consequently, the short seller must pay the lender any dividend or interest payments due on the security during the period that the seller holds the short position. When these payments are in cash, it is clear from the statute that any short seller may deduct the payments as investment interest so long as the security sold short is not a tax-exempt security. See I.R.C. §§ 163(d)(3)(C), 265(a)(5) (1988). The terms of the statute include as deductible any amounts “paid or incurred,” see id., but it is not clear that these terms cover imputed interest since the short seller does not owe that interest to anyone.

A zero coupon bond will tend to appreciate in an amount equal to the imputed interest, thereby creating a loss in that amount for the short seller. Because the short seller cannot deduct the imputed interest payments directly, he must deduct them as a loss (to the extent they are reflected in appreciation of the bond) upon closing the short position. This result is disadvantageous for the short seller (compared to deducting each year’s imputed interest payments against ordinary income) because the loss will often be a capital loss and the short seller cannot deduct the loss until the time of sale.

A 1972 Revenue Ruling suggests that the government will treat obligations of a short seller other than cash payments discharging dividend or interest obligations as amounts paid for replacing a borrowed security, which are nondeductible capital expenditures. See Rev. Rul. 72-521, 1972-2 C.B. 178 (holding that a short seller of stock may deduct payments covering cash dividends on the stock but may not deduct either the payment of a nontaxable liquidating dividend or the cost of covering additional shares from a nontaxable stock dividend). However, this Revenue Ruling is factually distinguishable because it disallowed deductions for nontaxable dividends. The imputed interest from zero coupon bonds is taxable.

In general, to achieve consistency, a tax system must treat opposite positions symmetrically. In other words, the tax treatment that applies to a short position must be the negative of tax treatment for the corresponding long position. Otherwise, combining equal long and short positions would result in a net tax effect even though the net cash flow is zero. Although special treatment (such as zeroing out the tax results) might be accorded to any situation where a short and a long position offset each other, such treatment might not be very effective. A taxpayer could avoid the required special treatment by constructing positions that fall short of, but come close to, perfectly offsetting short and long positions. For a more complete discussion of this “approximate arbitrage” maneuver, see text accompanying notes 80-84 infra.

52. The writer of a call option would receive symmetric treatment. Symmetric treatment of short and long positions is necessary to ensure consistency. See note 51 supra.
pared to the $300 initial value of the underlying asset, $C(0)$. As a result, $100 of imputed borrowing is appropriate under the generic rule as well.53

This generic rule for call options conflicts with the treatment of options under current law, which does not impute borrowing to the holder.54 However, given the predetermined treatments of the stock and the 2-year zero coupon bond, consistency requires that an imputed borrowing rule apply to at least the $C(121)$ call option.

One response to this problem would be to revise the current rules for taxation of options. This reform would be very limited in scope, involving only three sections in the Code.55 Reform of the option rules therefore could be regarded as an easy step that would be worthwhile if it led to a coherent way to tax new financial products.

Unfortunately, reforming the tax treatment of options will not suffice to ensure successful implementation of the spanning method. Other ambiguities and tensions deeply embedded in current tax law create substantial impediments. One example is the distinction between “stocks” and “bonds.” This distinction is so ambiguous that direct inconsistencies in taxation result.

Suppose, for example, that a corporation engages in a project with returns of $242, $363, $484, $605, and $726 in states A, B, C, D, and E, respectively. In terms of the 5-state economy example, this project generates returns equal to the returns from holding one share of the stock and one 2-year zero coupon bond. Consistency would require taxing the 2-year bond portion of the project under an OID approach. Under current law, however, if the corporation finances the project with equity, it can defer the tax on all of the project’s returns until the end of year two. In short, current law prescribes sharply different treatments for stocks and bonds without making clear the relevant distinguish-

53. This generic treatment does not accord with the most general form of the put-call parity equation. That equation shows that the value of a call is equal to the value of the asset minus the present value of a loan plus the value of a put. The put has the same exercise price as the call, and the loan represents the obligation to pay the exercise price on the expiration date of the option.

Although the suggested treatment in the text neglects the put, including the put value in the formula does not present a consistency problem. Because the stock yields a minimum of $121, the value of puts at strike prices of $0 and $121 (corresponding to the calls $C(0)$ and $C(121)$) would be zero, and these puts would not result in any cash flows. See note 50 supra. Consistency requires there be no tax consequences from any such “investment.” See text accompanying notes 12-13 supra (arguing that arbitrage transactions that cost nothing and yield no net cash flows should not have any tax consequences); cf. text accompanying notes 46-47 supra (noting that consistency may require tax on a zero cash flow outcome for an investment that is costly and that produces nonzero cash flows in some states of the world). As a result, adding these worthless puts to any portfolio will not affect the sum of the tax treatments of the assets from the portfolio.

54. Sale of an equity option before it expires results in either a capital gain or capital loss, which will be short or long term depending on the holding period for the option. If the option expires worthless, the tax laws treat the expiration as equivalent to the sale of the option on the expiration date for $0. Exercising a call option results in the addition of the option price to the price paid for the stock for purposes of determining the total cost basis of the stock. See I.R.C. § 1234 (1988 & Supp. IV 1992).


55. I.R.C. §§ 1234, 1234A & 1256 (1988). Commentators have argued that the current treatment of options impedes the effort to design rules for taxing new financial products and has little or no justification on tax policy or tax theory grounds. See, e.g., Hariton, New Rules, supra note 3, at 239; Kleinbard, supra note 3, at 950-51.
ing characteristics. Indeed, even the paradigmatic stock in the 5-state example contains a built-in bond component.56

The spanning method cannot resolve ambiguity that runs this deep. If tax policy requires distinct treatments for stocks and bonds, these categories must be defined much more precisely. Implementing precise definitions, however, would require fundamental and comprehensive reform, overturning familiar tax treatments for numerous financial instruments.57

Professor Reed Shuldiner’s rule of “expected value taxation” provides an example of this kind of reform. This rule divides financial instruments into a noncontingent portion representing the expected return from the instrument and a contingent portion representing deviations from that expected return.58 The rule would treat the stock in the 5-state example as the sum of three 2-year zero coupon bonds and a risky residual component with zero initial value:59

**TABLE IV: THE STOCK AND ITS CONTINGENT AND NONCONTINGENT COMPONENTS**

<table>
<thead>
<tr>
<th>State</th>
<th>Stock</th>
<th>Noncontingent Component</th>
<th>Contingent Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$121</td>
<td>$363</td>
<td>-$242</td>
</tr>
<tr>
<td>B</td>
<td>$242</td>
<td>$363</td>
<td>-$121</td>
</tr>
<tr>
<td>C</td>
<td>$363</td>
<td>$363</td>
<td>$0</td>
</tr>
<tr>
<td>D</td>
<td>$484</td>
<td>$363</td>
<td>$121</td>
</tr>
<tr>
<td>E</td>
<td>$605</td>
<td>$363</td>
<td>$242</td>
</tr>
</tbody>
</table>

This approach eliminates bond/stock ambiguities by providing a determinate way to isolate the bond component in any risky investment. However, applying this method across the board would require substantially revising the current treatment of equity instruments.60

56. The stock returns at least $121 in all five states of the world. See Table I supra.
57. Rules that rely heavily on the fragile distinction between equity and debt also create major problems in corporate law. See Hu, Shareholder Welfare, supra note 2, at 1286-1300 (noting that whether a security is equity or debt or a known hybrid affects the legal rights of the holder and that financial innovation has produced many instruments that are hard to categorize).
58. See Shuldiner, supra note 10, at 284-85.
59. Three 2-year zero coupon bonds would cost $300 at time 0 and yield $363 in all states of the world at the end of year two. Since the stock’s value at time 0 is $300, the value of the contingent portion of the stock that remains after subtracting the three bonds must be $0. Table IV also illustrates why the contingent portion has zero value. The expected return of the contingent portion is $0, and risk-neutral investors will value an asset with zero expected return at $0.
60. In addition, applying this approach (or another approach with a similar ability to clarify the bond/stock distinction) only to new financial instruments will not result in consistency. The inconsistency problem arises from the tax treatment of old financial instruments: Bond/stock combinations with identical cash flows incur different tax liabilities under existing rules. Furthermore, applying a generic treatment to new financial instruments may introduce new inconsistencies into the tax system. One may be able to invent new instruments that replicate the returns of the bond and stock assets to which the old rules apply. For example, an appropriate mixture of assets
D. A Perspective on the Results

The previous sections demonstrate that a tax system can be consistent and universal even when it treats certain classes of transactions quite differently. For example, one type of asset might be subject to an accretion rule while another is subject to a realization rule.

However, the flexibility in choosing tax treatments is not unlimited. If the tax law overconstrains the system by specifying a tax treatment for too many assets, the spanning method will fail. In particular, the number of distinct predetermined tax treatments cannot exceed the number of states. In addition, even if there are many states (as there undoubtedly are in the real world), a universal and consistent tax system cannot contain direct inconsistencies such as that between the current tax treatment of options and the current tax treatment of stocks and bonds. Finally, even if the system is not overconstrained and does not contain direct inconsistencies, choosing radically different theoretical approaches for particular paradigmatic transactions can prove costly in terms of tax system aesthetics: Consistency may require a tax treatment for some transactions that does not make sense under any theoretical or conceptual approach. For example, investors may have to pay a significant tax in some instances where there is zero net income and zero net cash flow.

Unfortunately, reform of the current system would require much more than simple adjustments and the acceptance of unpleasant aesthetics. Although it would be easy to remove some of the current system’s inconsistencies, such as those stemming from the tax treatment of options, only comprehensive reform could remove others, such as those stemming from the lack of a clear delineation between stocks and bonds. A quick survey of current tax law reveals many potential sources of additional inconsistencies and ambiguities: the dis-

from the set \( \{P(A), P(B), P(C), P(D), P(E)\} \) consisting of insurance portfolios can replicate the payoffs of the stock:

\[
S = $121 \ P(A) + $242 \ P(B) + $363 \ P(C) + $484 \ P(D) + $605 \ P(E).
\]

Unless the generic treatment for this mixture of insurance portfolios is the same as the treatment of the stock under the existing rules, inconsistency will result.

Specifying a tax treatment for a particular type of “target” asset requires that the combination of minimal spanning set elements that is equivalent to that asset receive the same tax treatment. If the number of distinct elements in the minimal spanning set that make up the combination is \( N \), a policymaker may choose tax treatments arbitrarily for only \( N-1 \) minimal spanning set elements, as the system must tax the remaining element in such a way that the entire combination receives the same tax treatment as the target asset. Thus, the cost of requiring a predetermined tax treatment for any one target asset is a loss of the freedom to specify the tax treatment of one element of the minimal spanning set, and imposing particular tax treatments on \( N \) target assets or portfolios in the economy requires specifying the tax treatment of \( N \) elements of the minimal spanning set. See text accompanying notes 48-52 supra (demonstrating that imposing specific tax treatment on two target assets, stocks and bonds, determines the tax treatment of two elements of the minimal spanning set). Since the number of assets in the minimal spanning set equals the number of states, see note 39 supra and accompanying text, the ability to impose a predetermined tax treatment for any additional target asset ends when the number of target assets with predetermined treatment equals the number of states. At that point, the restrictions on the system determine the tax treatment of every asset in the minimal spanning set and thus every asset or portfolio in the economy.

61. See text accompanying notes 49-55 supra.
62. See text accompanying notes 46-47 supra.
63. See text accompanying note 56 supra.
tinction between capital and ordinary treatment, the “double taxation” of corporate income, the asymmetry in treatment between gains and losses, nonlinear (e.g., progressive) rate structures, and the body of source rules that deal with foreign taxpayers. In addition, the difficulties for the spanning method revealed by examining a simple economy as in the sections above would persist or intensify in a more realistic model with more than five periods and more than two states.65

The positive result that the spanning method can produce a consistent and universal tax system in the face of disparate tax treatments for different asset types is nonetheless interesting. Even substantial reform is likely to result in a “hybrid” tax system that does not apply the same treatment to all assets. It is useful to know that such systems may accommodate theoretically distinct approaches for different assets and still be consistent and universal. Furthermore, as discussed in the next Part, several approaches currently advocated for dealing with new financial products can only be successful if they reduce to the spanning method.

II. BEYOND THE SPANNING METHOD: A GENERAL FRAMEWORK

As noted above, the prevailing view seems to be that global pattern taxation is the only comprehensive solution to the problem of taxing new financial products.66 If a particular generic tax treatment, such as accretion taxation or cash flow taxation, applies to all existing financial instruments, the government can simply apply this same treatment to any new financial product. While difficulties in implementation that require approximations and compromises might arise,67 the approach would be clear and coherent.

The previous Part shows that by using the spanning method it is possible to design a consistent and universal system for taxing new financial products that does not require prescribing a comprehensive treatment for all transactions. The above analysis does not indicate, however, whether the spanning method is the only approach that provides this result. In fact, spanning method approaches are only a subset of all successful approaches. Some alternative approaches are less restrictive but still yield consistency and universality.

This Part aims to provide a logical taxonomy of theoretical approaches for designing tax systems and then to relate this taxonomy to practical approaches, such as bifurcation and integration. To accomplish these tasks it is necessary to develop several refinements of the concept of consistency.

65. The real world obviously includes more than five outcomes and two time periods. Although increasing the number of states would increase the freedom to specify tax treatments, direct inconsistencies would not vanish. In addition, an increase in the number of states would make computing the proper tax treatment for a new asset more complex and probably would lead to worse tax aesthetics.
66. See text accompanying notes 13-16 supra.
Section A shows that all taxation methods that are consistent and universal can be expressed as integration schemes. Thus, the class of successful bifurcation and local pattern approaches is a subset of the class of successful integration schemes. Section B introduces the property of linearity, a property that implies consistency, and states two principal results: First, any linear and universal tax system reduces to the spanning method; second, any consistent and universal bifurcation approach must be linear. Thus, bifurcation approaches that are consistent and universal are equivalent to the spanning method. In addition, local pattern taxation will be consistent and universal only if it reduces either to the spanning method or to an integration scheme. Section C explores integration schemes. These schemes can provide a consistent and universal tax system even when the system is not required to be linear. This trait is important because modern tax systems tend to have significant nonlinearities. Section C also develops the concept of continuity, a condition that is weaker than linearity but stronger than consistency, and shows that all continuous and universal tax systems reduce to an integration scheme. In contrast, the spanning method will only succeed if the tax system is linear as well as continuous and universal. Continuity is important because its absence creates the same undesirable effects that follow from inconsistency.

A. Entire Integration and Consistency

Combining a taxpayer's portfolio into one single position and then associating a tax treatment with that position is a form of integration called "entire integration."\textsuperscript{68} Since any universal and consistent tax system associates to each total position a unique tax treatment, the following principle is true: 

\textit{The Entire Integration Principle}: Any consistent and universal tax system is equivalent to an entire integration approach.

Some integration approaches may aggregate only certain groups of instruments but not the taxpayer's complete portfolio. Under the Entire Integration Principle, however, any consistent and universal integration method can be treated as if it did integrate the whole portfolio, since each aggregate position

\textsuperscript{68} Mathematically inclined readers will realize that there is an easy way to describe any entire integration scheme. It is a function that maps the vector space of portfolios into a vector space of tax outcomes.

It is easy to see that the set of all portfolios, as well as the set of all portfolio returns, see note 39 supra, forms a vector space. First, choose a particular minimal spanning set. Each portfolio is a unique combination of assets in this set. The amounts of each minimal spanning set asset in the portfolio are the coordinates of the portfolio in the vector space. In the text example, this vector space is a five-dimensional Euclidean space.

The space of tax outcomes consists of vectors specifying how much tax will be paid at the end of each period in each state of the world. In the text example, these vectors will be 10-dimensional, each representing the taxes paid at the end of years one and two in each of the five states of the world. Of course, the set of all possible tax outcomes in the example will be isomorphic to a space with fewer than 10 dimensions since the taxes paid at the end of the first year are not contingent on the state of the world. See text accompanying notes 36-37 supra.

If we denote the space of portfolios as P and the space of tax outcomes as T, then an entire integration scheme is a function \( \Theta \) that maps P into T. Requiring that \( \Theta \) be a function (rather than a correspondence) captures the feature that an entire integration scheme specifies a unique set of tax outcomes for each portfolio.
must result in the same tax treatment no matter which combination of components led to the position. Furthermore, any method that achieves consistency and universality can be expressed as an entire integration scheme. Thus, all consistent and universal bifurcation methods and all consistent and universal local pattern approaches belong to the set of consistent and universal integration approaches.

The spanning method is one particular method of bifurcation that assures consistency and universality. The Entire Integration Principle indicates that the class of consistent and universal tax systems are precisely those that are equivalent to an entire integration scheme. Do all such systems also reduce to the spanning method? The answer is that they do not. The next section shows that the class of universal tax systems that reduce to the spanning method is precisely the class of all such systems that are linear. Some entire integration schemes are not linear and thus do not reduce to the spanning method.

B. Linearity, Bifurcation, and the Spanning Method

A tax system is linear if the tax treatment of an asset or portfolio is the sum of the tax treatments of the components that make up the asset or portfolio. Linearity requires that the tax treatment of any portfolio remain the same regardless of the manner in which the portfolio is divided into particular assets. As a result, linearity implies consistency. Section C shows that there are consistent tax systems which are not linear. Thus, linearity is a stronger condition than consistency.

The class of tax systems that are both linear and universal is exactly the class that can be implemented by the spanning method:

Spanning Method Principle: Any universal and linear tax system is equivalent to the application of the spanning method using any minimal spanning set. Conversely, the spanning method will result in universality and linearity under any choice for the minimal spanning set.

Proving this principle is straightforward. Suppose a tax system is universal and linear, and choose any minimal spanning set. Since the system is universal, it prescribes a tax treatment for every asset, including each asset in the chosen minimal spanning set. Since the system is linear and since it is possible to express any cash flow pattern as a combination of assets from the minimal spanning set, the tax treatment of the spanning set elements uniquely determines the tax treatment for all cash flow patterns and assets. Thus, all linear and universal tax systems reduce to the spanning method. The converse is also true: The spanning method guarantees that the tax system is linear and universal.

69. It may be helpful to define linearity mathematically using the framework of note 68 supra. In that framework, a function \( \theta \) that maps portfolios to tax outcomes represents the tax system. That system will be linear if, for any two portfolios \( x \) and \( y \) and for any two numbers \( q \) and \( r \) (representing ways of mixing the portfolios), \( q\theta(x) + r\theta(y) = \theta(qx) + \theta(ry) = \theta(qx + ry) \).

70. The converse follows from the assumption that the rule for computing the tax on combinations of minimal spanning set assets under the spanning method is linear. See text accompanying notes 43-45 supra. A portfolio is a weighted sum of a collection of assets, and each asset, in turn, is a unique
There is a natural connection between the concept of linearity and bifurcation methods. "Pure" bifurcation methods permit any decomposition of a particular portfolio for the purpose of computing taxes. An example is the bifurcation scheme in the 1991 version of the Treasury Department's Proposed Regulations for contingent debt. This scheme does not specify a particular method of decomposing contingent debt into pieces in order to compute the tax treatment of the whole. Critics of bifurcation in general, as well as critics of the specific proposal in Treasury's 1991 Proposed Regulations, emphasize the possibility that different decompositions may lead to different tax treatments. This problem will exist unless the tax system is linear. Linearity requires that the tax treatment of the whole be the sum of the tax treatments of the parts, so that it is a necessary condition for pure bifurcation to work. But linearity is also a sufficient condition since it implies consistency. In a linear system, different decompositions cannot lead to different aggregate tax consequences.

Pure bifurcation, such as the scheme envisioned in the 1991 contingent debt regulations, will not work in a nonlinear tax system. In such a tax system there will be at least one portfolio and at least one decomposition of that portfolio under which the sum of the tax treatments of the parts does not add up to the tax treatment of the whole. To be consistent, the tax system cannot permit an arbitrary decomposition of any such portfolio for tax purposes. Instead, the tax system must assign a specific tax treatment to the portfolio that is independent of the treatment that would emerge from summing the taxes under particular decompositions. This feature is the hallmark of integration: The taxpayer does not have the freedom to characterize a transaction or portfolio position according to the tax treatments of the pieces but must apply a single specified tax treatment to the whole. To avoid the requirement of linearity and still retain consistency, an element of integration must be mixed with any bifurcation approach.

Local pattern taxation does not require much additional discussion. As demonstrated above, every consistent and universal tax approach is equivalent canonical combination of assets from the minimal spanning set. The portfolio is also a unique canonical combination of spanning set assets. Since each cash flow pattern has a unique representation in terms of minimal spanning set assets, the canonical combination for the portfolio must equal the sum of the canonical combinations for the assets comprising the portfolio. Because the rule for computing the tax on combinations of minimal spanning set elements is linear, the tax on a combination from that set must equal the sum of the taxes on the components in any linear decomposition of that combination. As a result, the tax on any portfolio will equal the sum of the taxes on the assets that comprise the portfolio.

72. See note 7 supra and accompanying text.
73. See note 14 supra and accompanying text.
74. For example, one might bifurcate according to one minimal spanning set for one type of transaction and according to a second minimal spanning set for another type. See note 43 supra and accompanying text. This approach would result in a tax system that is not linear if the tax treatments of certain transactions depend on which spanning set applies. To ensure consistency, the tax system would have to specify the treatment of such transactions, independent of the treatments that might arise from some possible decompositions. An element of integration would therefore be present.

The spanning method avoids the need to use integration by requiring that one particular minimal spanning set be chosen for decomposing all instruments. See text accompanying note 43 supra.
to some integration scheme. 75 Moreover, it is possible to implement any linear and universal system using a bifurcation scheme based on the spanning method. 76 Departures from linearity require that the tax system include an integration element in order to maintain consistency. 77 Whether a system that employs local pattern taxation is linear or nonlinear, therefore, this ostensibly alternative approach is actually extraneous, at least for analytic purposes.

C. **Integration Revisited: Nonlinear Tax Systems and Continuity**

Integration by definition ignores the composition of portfolios in favor of their aggregate. As a result, under integration, a tax system can be consistent without being linear: The sum of the tax treatments of assets in a portfolio need not equal the tax treatment of the portfolio. Since linearity demands more of a system than consistency, the spanning method, which entails linearity, represents only a subset of all consistent and universal integration approaches.

Since every consistent and universal tax system reduces to an entire integration scheme, 78 classifying consistent and universal tax systems is a matter of classifying entire integration approaches. One part of this task is finished. From the Spanning Method Principle, 79 it is clear that the set of all linear and universal systems encompasses precisely the set of all systems that reduce to the spanning method:

**Linearity Property:** An entire integration scheme (i.e., any consistent and universal tax system) is linear if and only if the scheme can be generated by the spanning method.

To further refine the classification of integration approaches, it is useful to introduce continuity, a concept that lies between linearity and consistency. An entire integration scheme is "continuous" if portfolios that are nearly identical have nearly identical tax treatments. 80 In particular, small changes in any portfolio will not cause a "jump" in the tax results.

75. See text accompanying note 68 *supra*.
76. See text accompanying notes 69-70 *supra*.
77. Cf text accompanying notes 73-74 *supra*.
Introducing a local pattern may create nonlinearities. Specifically, if a particular portfolio of old instruments adds up to a new instrument subject to the local pattern, nonlinearity and inconsistency will result unless the sum of the tax treatments of the old instruments in the portfolio happens to be equal to the tax treatment that conforms to the local pattern. Avoiding inconsistency in this situation by ignoring the tax treatments of old instruments when they are combined to produce a new instrument amounts to an integration approach.

The ABA Report on the tax treatment of contingent debt advocates an integration strategy as part of a local pattern approach. In particular, the Report calls for integrating the contingent portion of such debt and taxing that part as a unit under a set of generic (local pattern) rules rather than attempting to decompose it into component parts. See *ABA Report, supra* note 3, at 1189, 1195 (recommendations (13) & (15)-(20)). The stated rationale for this proposal is that bifurcation is a poor vehicle for achieving consistency because there is no unique way to decompose the contingent portion of the debt. See id. at 1194-95. However, the Report is also skeptical about whether the integration approach itself could succeed in achieving consistency. See id. at 1195.

78. See text accompanying note 68 *supra*.
79. See text accompanying notes 69-70 *supra*.
80. More rigorously, a tax system is continuous if, for any position and any positive number (no matter how small), one can choose a range of portfolios surrounding the position such that the tax treatment of each portfolio in the range differs from the tax treatment of the position by less than the
Continuity is a stronger property than consistency. A tax system is consistent if a unique tax treatment exists for each cash flow pattern and if the law treats long and short versions of each position symmetrically. Continuity adds the requirement that the difference in tax treatment for any two positions must approach zero as the two positions converge.

A policymaker who values consistency will value continuity for the same reasons. More importantly, the absence of continuity may vitiate many of the benefits of consistency. Consider, for example, a consistent but discontinuous system in which tax treatments change abruptly at a particular “jump” point. An investor could achieve “approximate” tax arbitrage by matching a long position very close to the jump point with a short position exactly at that point. While the pretax net cash flow from these two positions can be made arbitrarily close to zero, the investor would experience a significant net tax effect. Thus, a system that is consistent but discontinuous fails to prevent tax manipulations similar to those possible in an inconsistent system.

As mentioned above, continuity implies consistency and therefore is a stronger requirement to impose on a tax system. However, continuity is a weaker requirement than linearity. Under fairly innocuous assumptions about the finiteness of taxes, it is a mathematical fact that linearity implies continuity. For this statement to make sense mathematically, one must specify a norm for the vector space of positions and a norm for the vector space of tax outcomes. For example, if one chooses the Euclidean distance norm for both spaces, then for any two vectors \( x \) and \( y \) in \( N \)-dimensional space, \( \| x - y \| \), the norm of \( x - y \), is the square root of the sum of the squared differences between the coordinates of \( x \) and \( y \). Given a norm, the usual definition of continuity applies: An entire integration scheme \( \theta \) that maps from the space of portfolios to the space of tax outcomes is continuous if, for any position, \( p \), and for any \( \varepsilon > 0 \), there is a \( \delta > 0 \) such that \( \| p - p^* \| < \delta \) implies that \( \| \theta(p) - \theta(p^*) \| < \varepsilon \).

81. See note 51 supra.
82. See text accompanying notes 12-13 supra.
83. Suppose, for example, that the tax system is consistent but that a particular point exists where ordinary income treatment replaces capital gain treatment. Suppose also that portfolios near this point produce gains in most states of the world. One could set up a long position slightly on the capital gain side of the discontinuity and a short position slightly on the ordinary income side. By moving these positions closer and closer to the point of discontinuity, one could make the combined cash flow from the positions arbitrarily close to zero. At the same time, the tax treatments of the two positions will match capital gains on the long side against ordinary losses on the short side, thereby creating a net tax advantage (conversion of ordinary income to capital gain income) with virtually no net pretax cash flow. The tax advantage will not diminish as the positions move closer and closer together, so long as they remain on opposite sides of the discontinuity. The taxpayer will have achieved approximate tax arbitrage. See text accompanying notes 12-13 supra (illustrating “pure” tax arbitrage in a similar example where a taxpayer can reduce pretax cash flow to zero).
84. Concern for continuity is evident in the tax policy literature. For example, the ABA Report on the treatment of contingent debt proposes to exclude instruments with de minimis contingent payments from the ambit of the contingent debt regulations. This measure would prevent issuers from being able to elect contingent debt treatment merely by including a nearly valueless contingent payment in the debt package. See ABA Report, supra note 3, at 1192. A continuous tax system would preclude such manipulations.
85. Continuity requires that each portfolio map to a unique tax treatment. For a definition of continuity, see note 80 supra and accompanying text.
86. The only assumption necessary is that the tax liability for any finite collection of assets will be finite. This assumption holds true if a finite minimal spanning set exists such that one unit of each asset in the set incurs a finite tax in every state of the world. The assumption is reasonable given that real world economies do not produce infinite returns.
In contrast, functions can be continuous but not linear. Consequently, there are continuous and universal tax systems that cannot be generated by the spanning method. Because integration schemes (at least entire integration schemes) can generate these same tax systems, it is clear that integration provides policymakers with a more general method for achieving desirable tax results than any approach that reduces to the spanning method:

_The Integration Dominance Principle:_ Every continuous and universal tax system can be generated by an entire integration scheme. The spanning method, on the other hand, can only generate the subset of continuous and universal tax systems that also are linear.

Because bifurcation methods tend to succeed only in linear tax systems, the Integration Dominance Principle validates the common intuition among practitioners that integration approaches have greater potential than bifurcation methods.89

This greater potential has practical as well as theoretical significance. The current United States tax system has many nonlinearities. Only integration methods will achieve continuity or consistency in such a system. An example of a major nonlinearity in the current United States tax system is the asymmetry in the treatment of losses and gains. Suppose that a start-up company can do project A, project B, or both. Project A yields a $3000 profit or a $1000 loss with equal probability, while project B yields $1000 with certainty. If the company does only project A and sustains a $1000 loss, the company cannot deduct the loss immediately but must carry the loss forward and use it against future gains. However, doing projects A and B simultaneously results in immediate use of the loss since the loss offsets the $1000 gain from project B.

These loss carryforward rules result in a nonlinearity. To see why, suppose that a 40 percent tax rate applies to the company’s projects and that the company will do no projects other than A or B. The taxes arising from project A and B separately do not always add up to the tax arising from the projects when done together:

---

87. This result will be familiar to readers with some background in real analysis. A linear transformation between vector spaces is continuous if it is “bounded,” i.e., if all portfolios on the unit ball in the portfolio space have finite tax outcomes. Because all portfolios on the unit ball are weighted combinations of assets in some finite minimal spanning set, and because the tax system is linear, the finiteness of the tax vectors corresponding to the minimal spanning set assets guarantees continuity.

88. For example, the function $f(x) = x^r$, where $x$ is a nonnegative real number and $r$ is a positive real number other than zero or one, is continuous but not linear.

89. See, e.g., Kau, supra note 3, at 1005-07 (arguing for integration because it avoids the complexities inherent in bifurcation); ABA Report, supra note 3, at 1195 (advocating integration over bifurcation for the contingent part of debt).
TAXES FOR VARIOUS OUTCOMES AND PROJECT COMBINATIONS
(GIVEN A $1000 GAIN FROM PROJECT B)

<table>
<thead>
<tr>
<th></th>
<th>$3000 Gain Outcome for Project A</th>
<th>$1000 Loss Outcome for Project A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project A Alone</td>
<td>$1200</td>
<td>$0</td>
</tr>
<tr>
<td>Project B Alone</td>
<td>$400</td>
<td>$400</td>
</tr>
<tr>
<td>Projects A and B Together</td>
<td>$1600</td>
<td>$0</td>
</tr>
</tbody>
</table>

In the case where Project A yields a $1000 loss, the separate projects incur a sum of $400 in taxes, while doing the projects simultaneously results in zero tax liability.

The treatment of losses under current law is effectively part of an integration approach. That approach requires aggregating the income and deductions from all of a firm's projects and then applying a special tax rule if there is an aggregate loss. Because the ensuing tax system is nonlinear, the spanning method cannot generate the same result.

Despite the greater promise of integration methods, these methods are not a panacea for the current United States tax system. Any revision aimed at making the system consistent and universal must eliminate existing direct inconsistencies, such as the ambiguous treatment of stocks and bonds. This task would require fundamental reform, whether accomplished with integration approaches or otherwise.

III. SUMMARY AND CONCLUSIONS

A. An Overview of the Framework and its Application

Part II developed a variety of results. This section provides an overview of the results and discusses how they apply to the challenges posed by new financial products.

Before beginning the overview, it is important to point out the wide applicability of bifurcation and integration techniques. Many areas of tax law that do not explicitly deal with new financial products employ or could employ these techniques. For example, Part II mentioned the integration aspects of the loss rules in current law. Another more general example of integration is the power of administrators and courts to apply the doctrine of "substance over form." This doctrine permits those enforcing the tax laws to overlook individual "pieces" of a transaction and tax the whole transaction according to its actual overall effect.

90. See text accompanying notes 56-57 supra.
91. See Boris I. Bittker & Lawrence Lokken, Federal Taxation of Income, Estates and Gifts § 4.3.3 (2d ed. 1989).
92. See Knetsch v. United States, 364 U.S. 361 (1960). In Knetsch, the taxpayer offset an investment in annuities yielding 2.5% per year with debt carrying 3.5% annual interest. The 3.5% interest payments on the loans gave the taxpayer a current deduction, while the gain from the increased value of the annuities was both deferred and subject to favorable capital gains rates under the rules applicable at

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Additional examples of bifurcation approaches in current law stem from the body of rules that apply to the sale of sole proprietorships and partnership interests. In the case of a sole proprietorship, complete bifurcation determines the tax due upon sale. Rather than treat the business as an integrated entity, the tax system assigns a gain or loss, whether capital or ordinary, to each asset of the proprietorship as if the assets were sold individually. In contrast, the sale or liquidation of a partnership interest triggers a partial bifurcation approach. Gains upon sale of a partner’s share in certain “hot” assets, principally appreciated inventory and accounts receivable, are taxed as ordinary income instead of capital gain, the same treatment that would apply to a direct sale of those assets. However, the class of hot assets does not include all assets that would produce ordinarily income or loss upon sale. As a result, the bifurcation is incomplete.

Since bifurcation and integration pervade current tax law, the results developed in Part II concerning these approaches are useful outside the realm of new financial instruments. But there is also a deeper interrelationship. If current law uses flawed bifurcation or integration schemes, specific flaws can become focal points for tax-motivated financial creativity. It is the tax system’s failure to be consistent, continuous, or linear that creates situations in which investors can “choose” tax treatments based on alternative transaction structures.

It is worth summarizing the roles of the three principles, linearity, consistency, and continuity, with special emphasis on their implications for tax innovation. Linearity, the requirement that the sum of the taxes on the components of a portfolio add up to the tax on the whole portfolio under every possible decomposition, is the strongest of the three principles since it implies consistency and, under a reasonable finiteness assumption about taxes, continuity. Continuity is the second strongest since it is an enhanced version of consistency. Continuity requires convergence of tax treatments as positions converge to a single portfolio, while consistency requires only that any single portfolio have a single specified tax treatment.

the time. Although the taxpayer incurred net negative pretax cash flows throughout the transaction, the substantial tax advantages made the whole transaction profitable.

Using a substance over form approach, the Supreme Court denied the interest deduction for the borrowing. Id. at 366 (“[I]t is patent that there was nothing of substance to be realized by Knetsch from this transaction beyond a tax deduction.”). The Court implicitly applied an integration approach by considering the nature of the transaction as a whole rather than allowing individual tax treatment of its parts to govern.

93. See BITTKER & LOKKEN, supra note 91, ¶ 51.9. The seminal case establishing this rule is Williams v. McGowan, 152 F.2d 570 (2d Cir. 1945) (ruling that a business' assets are taxed individually upon the sale of the business).
95. In addition, partners can structure liquidations, adjust inventory holdings prior to sale, or make other adjustments to avoid the operation of the rules. See 2 WILLIAM S. MCKEE, WILLIAM F. NELSON & ROBERT L. WHITMIRE, FEDERAL TAXATION OF PARTNERSHIPS AND PARTNERS, ¶ 21.01-06 (2d ed. 1990).
96. See text accompanying notes 86-87 supra.
97. See text accompanying notes 80-84 supra.
Bifurcation methods will succeed in general only if the tax system is linear. The existence of significant nonlinearities in current law means that policymakers should be very cautious about trying to employ these methods. Practitioners quickly recognize opportunities to exploit nonlinearities when the tax law uses a bifurcation approach. Consider, for example, the bifurcation rule that applies to the sale of a partnership interest. The general rule is that sale or exchange of a partnership interest results in capital gain or capital loss. However, partnership holdings are divided into categories, and for assets in certain categories gain on sale is characterized as ordinary gain. One of these categories is "substantially appreciated inventory," which includes all of the partnership's inventory if that inventory has appreciated by at least 20 percent (over its adjusted basis) and comprises more than 10 percent of the partnership's noncash assets. The rule does not consider assets held by the partners outside of the partnership. Thus, to benefit from the lower rate on capital gains, the partners can contribute some of their noncash assets, such as short-term Treasury bills, to the partnership in order to ensure that inventories are less than 10 percent of the partnership's noncash assets. When the partnership is sold, the partners will receive cash in an amount equal to the assets that they have contributed, which they can reinvest in these assets. This set of maneuvers involves no actual change in the partners' portfolios, but reduces the partners' tax liability when the partnership interests are sold.

New financial instruments, by providing new methods for dividing up cash flow patterns, increase investors' ability to exploit nonlinearities. As the invention of new instruments becomes easier and less expensive, nonlinearities that coexist with bifurcation approaches in the tax code become a much more serious problem. Indeed, as mentioned above, some of these nonlinearities may be focal points for financial innovation. In addition, using bifurcation to address problems that arise from new financial products may fail, or even create new problems, due to existing nonlinearities in the tax system.

Unlike bifurcation, successful application of integration methods does not require linearity. With integration, however, continuity becomes a serious concern. If portfolios with nearly identical returns have widely divergent tax implications, a taxpayer can choose a radically different tax treatment by changing his portfolio slightly, or can engage in approximate tax arbitrage by simultaneously holding a short position in one of the two portfolios and a nearly offsetting long position in the other. An advanced financial engineering industry

98. See text accompanying notes 71-74 supra.
100. See id. § 751(a).
101. See id. § 751(a), (d)(1).
102. See MCKEE ET AL., supra note 95, ¶ 16.05 (noting that "noncash assets" under the 10% rule include short-term cash-like investments but not cash itself).
103. One can extend the continuity concept by requiring that tax consequences not change "too quickly" with any particular portfolio shift. Continuity guarantees that no sudden jumps in tax treatment occur as investors vary the composition of their portfolios. However, continuous tax rules can come arbitrarily close to rules containing a discontinuity if the continuous rules involve increasingly drastic shifts in tax treatment near a given point in portfolio space.
104. See note 83 supra for an example of approximate tax arbitrage.
that can produce new instruments at low cost exaceritates these problems by making finer gradations in portfolio choice possible.105

There are many familiar examples of discontinuities in current law. One need only look for boundaries that delineate abrupt changes in the aggregate tax treatment of an asset or transaction. The borderlines between capital and ordinary assets, between short- and long-term gains, and between passive and active income are major examples. Another is the substantially appreciated inventory test for partnership assets. A small change in a partnership's inventories or asset composition may determine whether gains on the inventories are ordinary or capital, and thus have significant tax consequences for the partners.106

Discontinuities encourage tax-motivated financial innovation because new financial instruments enable investors to closely approach the borderlines between tax treatments. A closer approach reduces the degree to which investors must alter the preferred pretax attributes of their portfolios in order to achieve desirable tax outcomes. Thus, when policymakers consider integration schemes, they must consider how these schemes exacerbate or alleviate the problems caused by discontinuities.

The serious administrative costs of discontinuities and nonlinearities are apparent from history. These flaws induce major struggles between taxpayers and the government, often accompanied by new legislation attempting to curtail abuse. For example, the distinction between capital and ordinary assets, the distinction between short- and long-term gains, and the substantially appreciated inventory rule have each resulted in massive ongoing administrative problems.107

105. Nearly offsetting short and long positions do not always indicate tax manipulation. These positions may signify attempts to hedge business risk where only approximate hedging is available at an acceptable cost. For example, a company that has issued bonds with a payment at maturity that depends on the price of 3-month Treasury bills at that time might wish to hedge these bonds with Treasury bill futures. Because the most heavily traded Treasury bill futures contracts have standard expiration dates in March, June, September, and December, see Darrell Duffie, Futures Markets 346, 350 & 353 (1989), there will be an imperfect match between the publicly traded Treasury bill futures and the Treasury bill price risk inherent in the company's bonds if the bonds mature in some other month. Contracting privately for a Treasury bill futures contract with precisely the right expiration date might be so costly that the company's best strategy is to settle for an imperfect hedge. Hedging business risks can serve socially valuable purposes. See note 109 infra.

106. The substantially appreciated inventory test causes a discontinuity by establishing an arbitrary point at which the treatment of an aggregate of assets, in this case inventories, abruptly changes. Given this discontinuity, it is not surprising that the test also results in a nonlinearity. See text accompanying notes 85-88 supra (showing that linearity implies consistency, so that a discontinuous tax system cannot be linear).

B. Tax Policy Implications

If current trends are any indication, the variety and heterogeneity of available financial products will continue to increase rapidly. Such growth threatens to create greater and more frequent problems for a tax system already riddled with inconsistencies and discontinuities. Hence, two profound challenges face those who create, administer, and interpret the tax code: First, how can Congress shape the tax code in directions conducive to a “good” tax system? Second, how should administrators and courts respond to the dynamic tax environment created by financial innovation given that they cannot alter the major choices made by Congress?

This article provides a theoretical structure useful for the debate about these questions. One can achieve consistency and universality by constructing a tax system with a single global pattern of taxation, such as cash flow taxation or accretion taxation. But this extreme degree of homogeneity is not necessary. A linear tax system relying on the spanning method can harbor radically different treatments for different financial instruments while still being consistent and universal. Even linearity is not required. Powerful and general approaches relying on integration methods can operate in a nonlinear environment. In fact, any consistent and universal set of rules is equivalent to an integration approach. However, an integration scheme must be continuous, rather than merely consistent, or manipulation through approximate tax arbitrage and other devices will be possible.

The current United States tax system contains not only nonlinearities and discontinuities but also direct inconsistencies. For example, the tax treatment of equity and debt differ substantially, but there is considerable overlap in these categories. As a result, to a significant extent, financial engineers can package the same set of cash flows to be equity or debt for tax purposes.

Repairing the major discontinuities and inconsistencies in current law is a task that would require fundamental reform. These discontinuities and inconsistencies arise from aspects of current law that are central to the statutory scheme, such as the debt/equity distinction, the distinction between capital assets and ordinary assets, and the differential treatment of gains and losses by holding period. Changing these fundamental aspects is only possible at the legislative level. Addressing major inconsistencies and discontinuities at that level would go a long way toward relieving the pressure arising from financial innovation since these flaws in the tax system tend to act as focal points that stimulate the development of tax-motivated new financial products. In addition, if administrators must take these inconsistencies and discontinuities as given and immutable, not even the most powerful integration techniques will succeed at making the tax system consistent or continuous.

Even if Congress implements major changes, it is likely that some significant inconsistencies and discontinuities will remain. This fact, and the darker possibility that no major reform will occur, create difficult choices for the
Treasury Department and the courts. Since no set of Treasury Regulations or cases can guarantee universality and consistency or continuity in the face of major inconsistencies and discontinuities, these authorities are necessarily limited to prescribing second best solutions. Perhaps the only viable alternative for dealing with new financial instruments is the traditional one of analyzing the normative stakes for each type of transaction and then crafting a detailed response.109 Since the stakes differ by type of transaction, comprehensive rules are not always desirable.110 Loose ends in the form of inconsistencies, discontinuities, or lack of universality will be inevitable.

109. Commentaries on the tax treatment of contingent debt provide a good example of this type of analysis. Issuers of contingent debt often hedge the contingencies by purchasing or issuing other financial instruments. This hedging allows the issuer to shift the risk on the contingent portion of the debt to others, thereby facilitating a transaction (issuance of contingent debt) that can reduce the issuer's borrowing costs while simultaneously making capital markets more efficient by providing investors with an instrument they want. See Kleinbard, supra note 3, at 954. To ensure that asymmetric tax treatment of the hedge position and the contingent debt will not discourage such transactions, several commentators have advocated integrating the two and treating the entire package as ordinary debt. See, e.g., id. at 953; ABA Report, supra note 3, at 1199-1200.

Not all corporate hedging transactions are socially valuable or good for shareholders. See Hu, Shareholder Welfare, supra note 2, at 1306-09 (noting that hedging by public corporations can be wasteful when it is costly but merely eliminates risk that shareholders can avoid by holding diversified portfolios). But business hedging can serve socially valuable purposes, for example, when investors cannot distinguish poor business performance from poor performance due to bad management. By hedging business profits, managers can eliminate the market fluctuation effect and thus provide clearer information to investors. The tax system should not discourage financial innovation that permits socially valuable hedging. However, the private and social costs of any particular financial innovation may be quite subtle. See Hu, supra note 1, at 1462-63, 1465-67, 1465 n.31; see also Hu, Regulatory Paradigm, supra note 2, at 338-42 (noting the increasing complexity of new financial products and their social costs). As a result, choosing the best tax treatment for financial innovation raises difficult issues pertaining to capital markets. Policymakers cannot always tell a priori which financial innovations are worth encouraging and which are not. In addition, it is not clear whether the tax laws are the appropriate vehicle by which to impose a subsidy or a burden.

The picture becomes more complicated in light of the rich set of tax motivations for hedging. A firm may hedge to reduce fluctuations in taxable income and thereby reduce the possibility of a delay, due to the loss carryforward rules, in its tax deduction for current losses. Hedging also allows a firm to borrow more. The tax code arguably discriminates against firms with low borrowing capacity, see Michael S. Knoll, Taxing Prometheus: How the Corporate Interest Deduction Discourages Innovation and Risk-Taking, 39 VILL. L. REV. (forthcoming March 1994), and crafting tax rules that favor hedging (or at least do not hinder it) may correct this discrimination. Clearly, these considerations suggest a whole host of second best tax policy issues. The policymaker's attitudes toward the corporate interest deduction, the treatment of losses, and even corporate tax integration are relevant.

110. For example, applying differing treatments to new instruments connected with different types of hedging transactions may be optimal. See note 109 supra. In any event, the accumulation of regulations, each responding to particular instruments or special problems, may be unavoidable. Proposals that call for common law development or a continuing dialogue among the Treasury, practitioners, and taxpayers are not necessarily a cop out. See note 16 supra and accompanying text. The gradualist theme in these proposals echoes Professor Henry Hu's more elaborate and general argument for an incremental, process-based approach to the regulation of new financial products. See Hu, supra note 1, at 1496; Hu, Regulatory Paradigm, supra note 2, at 413-14. Professor Hu stresses the informational disadvantages faced by regulators who must integrate new financial products into regulatory structures developed in response to existing financial instruments. Hu, supra note 1, at 1463, 1495-1508; Hu, Regulatory Paradigm, supra note 2, at 405-12. Although Professor Hu deals primarily with financial regulations, such as the capital adequacy rules that apply to banks, many of his arguments have obvious parallels for the design and administration of the tax laws in the face of financial innovation.