

NORGES HANDELSHØYSKOLE

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Macroeconomic Derivatives:

Overview and Sovereign Debt Market Applications

by **Andrei Filippov**

Advisor: Kristian Miltersen

NORGES HANDELSHØYSKOLE

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Introduction

The choice of the subject of this Master's thesis is primarily driven by the author's long-standing interest in innovative ideas and their realizations. Innovation in all spheres of human activity, in author's opinion, is the critical process that helps the humankind to constantly improve its general welfare. Innovation expresses itself most evidently in technical progress, which is creating previously unseen opportunities for enhancing the wellbeing of societies. During the past century, in particular, substantial economic gains from advances in natural science, management and information technology, among others, have been realized and continue to accrue.

Although much less obvious to many, the field of finance is making an important contribution to economic progress as well. Theoretical breakthroughs achieved in the second half of the twentieth century by academics of the field provided a new foundation for financial decisions, a comprehensive toolkit for achieving optimal allocation of assets and risk management. In practice, innovation has been promoted by exchanges, investment banking firms, insurance companies, brokerages, and international development banks. In the words of Robert Shiller, a Yale professor whose works have provided a source of inspiration for the author of this thesis, world financial centers have "served as the liveliest laboratory for new ideas in all of capitalism" (2003: 1). While this claim may seem a little overstated, innovations such as mortgage pass-through securities, real estate investment trusts (REITs), liquid-yield option notes (LYONs), index-linked certificates of deposit and bonds (e.g. TIPS in the US), and online discount brokerages, to name a few, rival major breakthroughs in real economy by their impact on the financial sector and the opportunities of economic agents. When well designed, financial innovations do an important job of improving the allocation of capital and sharing of risks.

At the same time, there is still plenty of room for research and innovation in finance. For example, there is a vast array of risks that remain practically hidden. These risks are not traded, not managed properly and not shared. One observation is that current stock markets trade claims on only a fraction of national income represented by corporate earnings. Outside the corporate markets, most income flows are not securitized and not traded. Consequently, existing derivatives markets provide opportunities for managing of only a limited set of risks.

At the same time, the risks currently excluded from intermediation can be substantial. For instance, individuals face a major economic risk related to their occupations, i.e. the risk to their household income. Essentially, it is the risk that their skills and talents become worthless, not required by enterprises or society at large. This risk appears to be growing, as the pace of technological change increases and businesses become ever more mobile internationally. Commonly, individuals try to avoid occupational risks by forgoing opportunities, e.g. choosing 'safe' careers. Livelihood risks have been also traditionally cushioned by family (to a certain degree), or reduced by means of income redistribution by governments and charitable organizations. The important role of these social institutions is undisputed, but their evidently low efficiency as risk management devices calls for better arrangements as well.

Ultimately, most agents in an economy incur macroeconomic risks, i.e. risks associated the performance of the overall economy. Many nations, both developed and developing, have gone through periods of economic success and failure. The well-known examples include the Great Depression; the disappointing performance of Japanese economy since 1989, after years of 'wonder'; the collapse of the Russian economy in 1998 and its strong recent performance; a deep crisis in Argentina in 2001-2002. It may seem that with the currently available amount of historical data and constantly developing body of theoretical knowledge we could essentially predict and manage, or at least soften, such downturns *ex ante*. In reality, however, economists often offer *ex-post* explanations for fluctuations in national incomes that are not entirely trustworthy or consistent. It is also possible that macroeconomic risks will always remain unavoidable, since the global economy behaves more like a constantly evolving organism, rather than a mechanic system. At the same time, macroeconomic risks remain largely unmanaged.

The presence of the unmanaged risks creates an opportunity for financial innovations that can help to re-allocate the risks efficiently. Those economic agents that would prefer to reduce or eliminate macroeconomic risks are likely to benefit from having an appropriate hedging tool at their disposal. Macroeconomic derivatives, i.e. derivatives indexed to macroeconomic indicators, appear to have the potential to fulfill this role. These derivatives already exist in practice and are starting to attract the attention of academic circles as well. Their innovative features and potential provided the author with a motivation for choosing macroeconomic derivatives as the broad subject of this thesis. The specific purpose of this work is to give a

comprehensive introduction to macroeconomic derivatives and to explore a particular area of their application. In an effort to make the discussion more practical and, at the same time, aligned with the international background and interests of the author, it was chosen to investigate closer the case of the use of GDP derivatives in conjunction with countries' external debt, which has acquired particular practical relevance in the light of the recent Argentina's bond exchange.

The thesis is organized as follows. The first chapter sets a basic theoretical background related to derivatives in general and options in particular. The second chapter provides a more detailed presentation of macroeconomic derivatives. It gives an overview of their features and peculiarities, their role and potential application. Further, it studies the history of macroeconomic derivatives and instruments similar in nature, with special attention to the evidence of market interest in these securities and major obstacles to their introduction. The final part of the chapter focuses on the current state of the markets for macroeconomic derivatives, including the Goldman Sachs/Deutsche Bank's Economic Derivatives platform and the new Argentine offering of bonds with GDP warrants. The third chapter is dedicated to a specific application of macroeconomic derivatives, namely the issuance of GDP warrants along with external sovereign debt. First, it builds the case for GDP-linked bonds by surveying the academic literature, explaining the mechanism of GDP-linked debt, discussing its benefits to borrowing countries, and suggesting the ways to overcome potential obstacles. The second part of the chapter considers GDP-linked bonds from the point of view of investors, listing the advantages and reporting the opinions of the market participants. Finally, the third chapter provides the results of a quantitative evaluation of potential yields of GDP-linked bonds, along with an important discussion of the methods of their valuation. A summary of the findings concludes the thesis.

1. General theoretical background

This chapter lays out a general theoretical background for derivative securities. The theory presented here is very basic, since at the moment macroeconomic derivatives are not extensively covered in the literature and some of the issues relevant to them are still not settled. Most of the relevant theory, thus, will be treated integrally in the discussion of the following two main chapters. The first section of this chapter provides a definition and classification of derivatives, and discusses their purposes. The second section reviews the characteristics of option contracts and common pricing formulas.

1.1 Derivatives

1.1.1 Definition and classification

Derivative securities can be generally defined as follows:

A financial contract is a derivative security if its value at expiration date T is determined exactly by the market price of the underlying cash instrument at time T (Neftci, 2000).

At expiration date T the price $F(T)$ of a derivative security is completely determined by the value of the underlying asset. After the expiration date, the derivative ceases to exist. This property of derivatives has important implications for their pricing. The value of derivative $F(t)$ is known deterministically only at exercise. The fact that the value of the derivative will be determined exactly in a known way also places some constraint on the prices of derivatives before expiration, thereby preventing speculative bubbles in the derivatives markets.

The underlyings of derivative securities can be categorized into five main groups:

1. Stocks (claims on returns generated by the real sector);
2. Currencies (liabilities of governments, but not direct claims on real assets);
3. Interest rates (notional assets designed to take positions in interest rates, as well as bonds, notes and T-bills);
4. Indexes (notional amounts linked to an index);

5. Commodities (physical assets, goods in kind).

Derivative securities are traded on two distinct types of markets: derivatives exchanges and over-the-counter market. The exchange-traded contracts typically have standardized terms (e.g. contract size, maturity, features of the underlying) and are traded on organized markets. Over-the-counter (OTC) contracts, on the contrary, have custom terms and are created through an agreement between two parties, typically a dealer (a financial institution) and a user of the derivative contract.

Derivative securities can be classified into two general groups: forward commitments and contingent claims. *Forward commitments* are obligations to buy or sell an underlying asset on a specified future date T at a forward price specified at the initiation of the contract. There exist two basic types of forward commitments: the OTC forward contracts and the standardized, exchange-traded futures. A distinct feature of forward commitments is that they are linear instruments: the payoff of these contracts at expiration is a linear function of the underlying asset's value.

Contingent claims, in contrast to forward commitments, give their holders a right to buy or sell an underlying asset at a price specified at the initiation of the contract (strike price). The right may be exercised on a specified future date T (for European-type contracts) or anytime before that date (for American-type contracts). Contingent claims are non-linear instruments, because their payoffs depend on the occurrence of a specific event. The holder of such contract will decide to exercise his/her right to buy or sell the underlying only under certain favorable conditions existing at the expiration date, or in other words, if a specific event happens. This feature makes payoffs of contracts of this type contingent on some event and, thus, non-linear. The most common form of a contingent claim is an option contract, which, in turn, can also be exchange-traded or OTC. Option-like features can also be embedded into other financial contracts, which makes them a form of contingent claims as well (see Fig. 2.2).

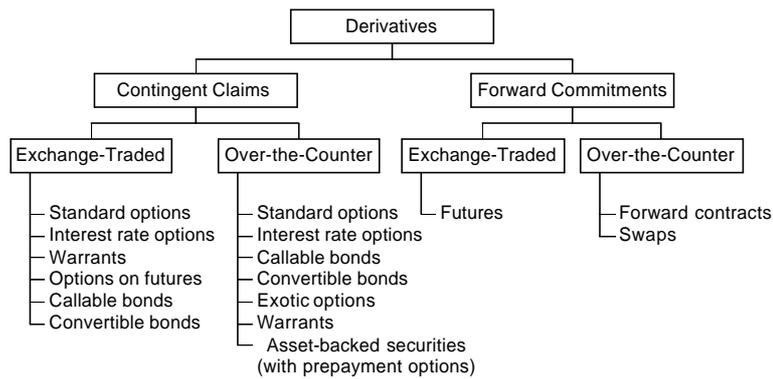


Figure 1.1 A classification of derivatives

Source: Chance (2003)

1.1.2 Purposes of derivatives markets

Derivatives markets serve several purposes in the economic system and financial markets. Futures markets, for example, fulfill an important function of price discovery. Futures prices provide valuable information about the market expectations regarding the future prices of the underlying assets. Futures price can be used as a proxy for the prices of the underlying assets, especially in place of the uncertain future prices. Option markets provide information on market expectations as well, but in a different manner: option prices can be used to determine the implied volatility of the price of the underlying asset.

The most important purpose of derivatives is, perhaps, *risk management*, which can be defined as process of modifying the actual level of risk to match the desired level of risk. This activity is often called ‘hedging’, which generally refers to the reduction or elimination of risk. The other side of this process is often called ‘speculation’. Hedging and speculation are traditionally seen as complimentary activities, where hedgers seek to eliminate risk and speculators seek to assume risk. However, both activities may interact and intersect one with another, so that it is not always possible to make a clear distinction between a hedging and a speculative strategy. Both of them involve taking a view on the future outcomes of the underlying variable, and both can be described as risk management.

Derivatives markets also serve the purpose of improving market efficiency for the underlying assets. Derivatives provide tools for exploiting arbitrage opportunities when they exist, and thus help to eliminate these same arbitrage opportunities and ensure fair and competitive asset pricing.

An additional benefit of derivatives markets is that they allow investors to reduce transaction costs. Trading in derivatives is typically much less expensive than trading in the underlying asset itself. A reason for such difference is that derivatives serve as a form of insurance and as such cannot have an excessively high cost relative to the asset being insured, or else they would not exist.

1.2 Options

Since a significant part of the thesis primarily deals with option-like securities, the rest of this background chapter focuses on derivatives of this type. This section proceeds to describe the general characteristics of option contracts and the most common pricing formulas.

1.2.1 Characteristics of option contracts

This subsection outlines the characteristics of the basic class of option contracts – stock options. The payoffs of option contracts at expiration are described and the factors affecting option prices before expiration are discussed.

There are two most common types of option contracts: call options, which give their owners the right to buy the underlying asset on or before a specified date, and put options, which give their owners the right to sell the underlying asset on or before a specified date. At expiration, the value of a European call option is either zero or the difference between the price of underlying asset and the exercise (strike) price, whichever is greater, i.e.

$$c_T = \max [S_T - K, 0] \quad (1.1)$$

Similarly, the value of a European put option is either zero or the difference between the exercise (strike) price and the price of underlying asset, whichever is greater, i.e.

$$p_T = \max [K - S_T, 0] \quad (1.2)$$

The payoffs of a call and put options to the buyer and the seller at expiration are demonstrated on Fig. 1.2.

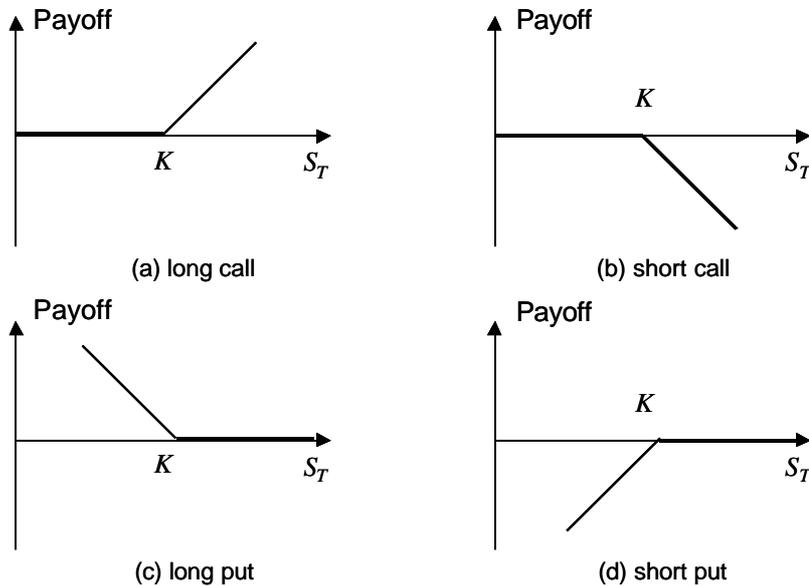


Figure 1.2 Payoffs of European-type options at expiration

Source: Hull (2003)

Before expiration, option prices are determined by several factors, instead of just the strike price and the value of the underlying. These factors are listed below:

1. Current price of the underlying (S_0),
2. Strike price of the option (K),
3. Time to expiration (T),
4. Volatility of the price of underlying (s),
5. Risk-free interest rate (r_f),
6. Cash flows associated with the underlying that are expected to be paid during the life of the option (e.g. dividends on a stock).

The two first factors affect the option price through their effect on the expected payoff of the option. In fact, it is the relationship between the two that influences the price of an option. The more the price of the underlying exceeds the strike price of a call option, the more the option becomes valuable. Similarly, the more the price of the underlying falls below the strike

price of a put option, the more the option becomes valuable. The difference between the current price of the underlying and the strike price, bounded below by zero, or in other words, the payoff of the option if it were exercised immediately, is called ‘intrinsic value’ of the option and constitutes one of the two components of the options’ value. For a call option, the intrinsic value is $\max(S_0 - K, 0)$, and for a put option $\max(K - S_0, 0)$. Figure 1.3 demonstrates the effect of the changes in the price of the underlying on the value of call and put options (fixed parameters are $K = 25$, $T = 5$, $s = 0.25$, $r_f = 0.05$, no cash flows expected).

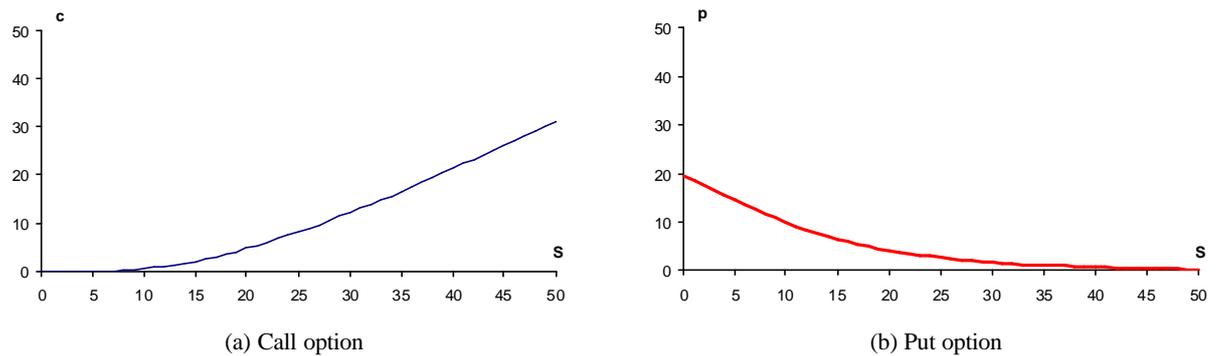


Figure 1.3 The effects of changes in underlying price on option values

Source: Author's calculations

Time to expiration typically has a direct relationship with the option price. For two options that differ by their expiration date but otherwise are identical, the option with a longer time to expiration is usually at least as valuable as the one with shorter time to expiration. For American options this relationship is even more pronounced, since a longer-life American option gives its holder more exercise opportunities than a shorter-life option. There may be some exceptions to the rule above: (1) far out-of-the-money or in-the-money options, for which additional time to expiration makes no difference, and (2) European puts, for the holders of which waiting additional time implies lost interest on the money they would have received from a shorter-life option and invested. In general, nevertheless, time to expiration contributes to the ‘time value’ of the option, which is the second key component of option’s value. In fact, time value is expected to decrease as time approaches the expiration date, so that the option’s value approaches the intrinsic value. Figure 1.4 demonstrates the effect of the time to expiration on the value of call and put options (fixed parameters are $S_0 = 25$, $K = 25$, $s = 0.25$, $r_f = 0.05$, no cash flows expected).

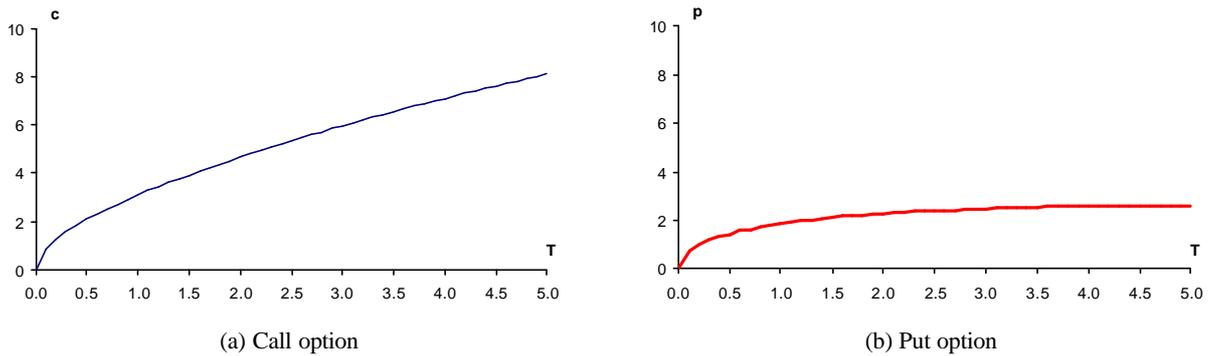


Figure 1.4 The effects of changes in time to expiration on option values

Source: Author's calculations

Time value of an option reflects the possibility of favorable future movements of the price of the underlying. This possibility, naturally, depends also on the volatility of the underlying. When volatility increases, it improves the chances that the option will have a good payoff when exercised. A rise in volatility increases the chances of unfavorable performance of the underlying as well, but the option holder is protected from negative payoffs by the design of the option contract. Thus, when volatility of an underlying asset increases, the value of the options written on this underlying also increases. Figure 1.5 demonstrates the effect of the changes in volatility on the value of call and put options (fixed parameters are $S_0 = 25$, $K = 25$, $T = 5$, $r_f = 0.05$, no cash flows expected). It is worth noting here that volatility is a critical factor for option prices, but at the same time it cannot be directly observed on the market.

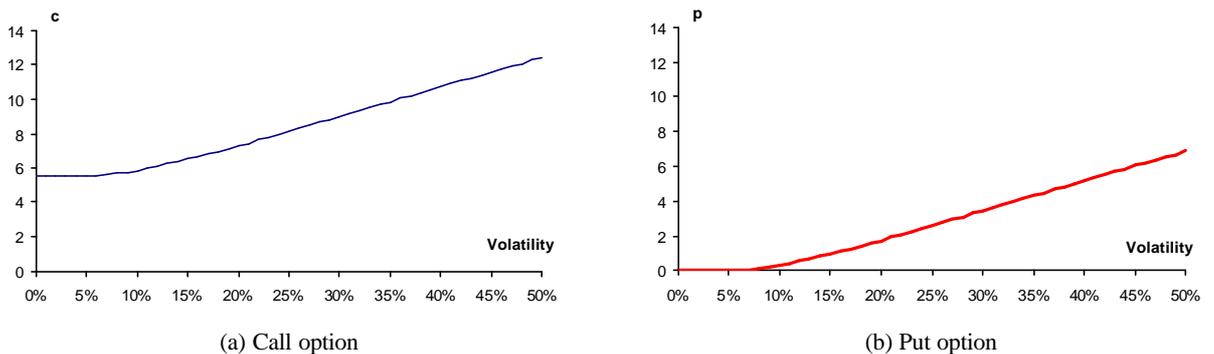


Figure 1.5 The effects of changes in volatility on option values

Source: Author's calculations

Interest rates affect option prices in a less obvious way. A call option can be represented as a leveraged position in an underlying. Thus, when the interest rates are high, buying a call instead of borrowing money to buy the underlying is more attractive. Conversely, put holders lose potential interest on the money they would have received from selling the underlying

asset immediately, and this opportunity costs makes holding a put less attractive when interest rates are high. Thus, rising interest rates increase the value of call options and decrease the value of put options.

The cash flows associated with the underlying asset influence option values through the price of the underlying itself. Such payments as dividends on stocks, coupon interest on bonds, interest on foreign currency, and carrying costs of commodities all have effects on the prices of the respective assets. For example, a dividend on a stock tends to decrease the stock's price. Consequently, the value of a call option would be reduced, and the value of a put option would be increased, in proportion to the amount of anticipated dividends on the stock.

1.2.2 *The Black-Scholes pricing formulas*

The use of Black-Scholes pricing formulas is now virtually the standard approach for the valuation of most European-type options. Their application is not limited to options on traded securities, as they can be employed in corporate finance and valuation of real options as well. This subsection briefly reviews the assumptions underlying the Black-Scholes-Merton model and presents the formulas themselves.

The model was first derived by using a no-arbitrage argument, i.e. that there are no riskless arbitrage opportunities. The other assumptions of the model are as follows:

- *Process followed by the underlying*: the price of the underlying variable is assumed to follow geometric lognormal diffusion process. This process in most cases does not correspond exactly to the reality, but it offers a convenient and reasonable approximation.
- *Development of the risk-free rate*: the model does not allow the risk-free rate to be random, assuming that it is known and constant. This assumption creates problems for pricing of options on interest rates and bonds. However, even for these options it is usually possible to obtain a reasonably reliable estimate of the options' value, especially when special adjustments are made (e.g. convexity and timing adjustments).
- *Development of volatility*: the volatility of the underlying assets is assumed to be constant during the life of the option and requires to be estimated, being one of the critical input factors. Obviously, the volatility of the underlying may change in reality, as it is usually

the case with stock prices, for example. Considerable research has been conducted in this area and models have been developed to deal with stochastic volatility.

- *Technical assumptions:* it is commonly assumed in derivatives pricing that there are no taxes or transaction costs involved in security trading. This assumption is clearly unrealistic, but it allows distinguishing the fundamental factors behind option prices. It is also possible to relax this requirement. Additionally, the Black-Scholes model assumes that the trading in the underlying is continuous, which is not very far from reality for securities trading daily or on electronic exchanges that function without closures.
- *Cash flows of the underlying:* the basic form of the Black-Scholes formula is valid only for the underlyings that do not pay any cash flows. However, the model is easily modified to accommodate the cash flows associated with the underlying asset.
- *Early exercise:* in most cases the Black-Scholes formula can be used only for European-type options. For American options, binominal model with a large number of periods is deemed more appropriate.

The basic Black-Scholes formulas for pricing European call and put options on a non-dividend paying security are as follows:

$$c = S_0 N(d_1) - X e^{-r_f T} N(d_2), \quad (1.3)$$

$$p = X e^{-r_f T} N(-d_2) - S_0 N(-d_1), \quad (1.4)$$

where

$$d_1 = \frac{\ln(S_0 / X) + [r_f + s^2 / 2]T}{s\sqrt{T}}, \quad (1.5)$$

$$d_2 = d_1 - s\sqrt{T}, \quad (1.6)$$

S_0 is the current price of the underlying, X the strike price of the option, r_f the continuously compounded risk-free rate, s the volatility (standard deviation) of the continuously compounded return on the underlying, T time to maturity, and $N(\bullet)$ is cumulative probability distribution function for the standard normal distribution.

2. Macroeconomic Derivatives

Macroeconomic derivatives are a special case among financial derivative contracts. They have particular characteristics and benefits, and their introduction and use presents particular challenges. Highlighting these peculiarities, this chapter provides an overview of the features of macroeconomic derivatives, their general role and applications, reviews the attempts of creating markets for these instruments, identifies the major obstacles that plagued these attempts, and, finally, describes the current state of affairs.

2.1 Overview

To provide the reader with an overview of macroeconomic derivatives, it is first useful to define these instruments and discuss the features that set them apart from other derivatives, and in particular the features of their underlyings. This section then proceeds to describe the theoretical role of macroeconomic derivatives and to suggest a number of practical applications and benefits.

2.1.1 Definition and features

The definition of derivatives provided in subsection 1.1.1 can be adapted to macroeconomic derivatives in the following way:

Macroeconomic derivatives are financial contracts whose value at the expiration date T is determined by the value of an underlying macroeconomic indicator at time T .

In a general sense, macroeconomic derivatives were first proposed by Marshall et al. in 1992. Specifically, they suggested to create a new class of swaps called ‘macroeconomic swaps’ and a related class of options – ‘macroeconomic options’. A macroeconomic swap would be similar to an ordinary fix-for-floating swap, but the floating leg of this swap would be tied to a macroeconomic variable such as GDP, orders for durable goods, wholesale price indices, etc. The end user and a macro swap dealer would exchange period payments based on the prevailing value of the floating macroeconomic variable and a fixed coupon rate.

Macroeconomic options have some macroeconomic index, or a function of such index, as their reference rate, in place of the underlying asset’s ‘price’. A macroeconomic option gives

its owner the right to receive at expiration time T the difference between the value of an underlying macroeconomic index or a function of such index at time T and the option's strike price K . For example, an option on GDP may have the following payout at time T (in per cent of its notional amount):

$$C_T = \max [g_T - g^*, 0], \quad (2.1)$$

where g_T is the actual GDP growth rate and g^* is the strike defined in terms of GDP growth, i.e. a 'baseline' growth rate. Currently, macroeconomic derivatives exist in practice mostly in the form of options on macroeconomic statistics.

Macroeconomic derivatives are certainly not limited to the particular types of instruments described above. Macroeconomic derivatives can be indexed to a variety of indicators, such as economic growth, inflation, real-estate prices or employment data. The group of macroeconomic derivatives may potentially include macroeconomic forwards and futures, or indeed any other type of financial instrument. Macroeconomic derivatives can also be embedded into other financial contracts (it is in this quality that they first manifested themselves in practice). Basically, it is not form of the financial contracts itself that is novel about macroeconomic derivatives, but their underlyings.

The distinct feature of macroeconomic derivatives is that their underlying 'assets' in most cases cannot actually be traded or held. For many conventional derivatives, the underlying assets are physical assets or claims on such assets that can be bought and sold in organized markets. A stock derivative has as an underlying a (usually) traded claim on the corporate profits. An interest rate derivative has as an underlying a notional asset that allows taking positions in interest rates. On the other hand, there is no such asset or claim for a derivative on inflation. Although one can arguably buy the goods that are included in the basket for the calculation of an inflation index, holding the goods even for a month might not be practicable.¹ In the case of a derivative on national income the underlying is even more complicated. While a claim on national income can be imagined (cf proposals by Shiller, 1993 and 2003) or even created (see the example of New Singapore Shares in subsection 3.2.2), no markets for such claims currently exist.

¹ It is now possible to replicate the underlying of an inflation-linked derivative by combining government inflation-indexed securities and nominal government securities (see 'CPI Futures at CME' in Section 2.3.2)

Contractually, the lack of a tradable underlying asset does not pose any problems for derivatives, since the latter can be made contingent on virtually any event, even weather-related. However, it creates another technical problem: the impossibility of arbitrage would leave the markets for macroeconomic derivatives without a mechanism of price convergence towards a ‘fair’, non-arbitrage value. Moreover, it makes the use of conventional pricing tools based on no-arbitrage arguments questionable, so market participants may find it difficult to obtain an estimate of a fair price for these securities.

There are also other distinctive properties of the underlyings of the macroeconomic derivatives. In contrast to conventional securities, which represent claims on the future cash flows of the corresponding assets, macroeconomic variables are ‘flow’ variables that measure an economic phenomenon during a certain period of time, and this feature, naturally, restricts the volatility of the macroeconomic variable. In addition, the values of macroeconomic indicators are typically reported in a discrete manner, with intervals between subsequent values ranging from a week to a quarter. This property constraints any macroeconomic option that does not span several announcements of the underlying data to be of the European type. Some of the macroeconomic variables that are good candidates for the underlyings of macroeconomic derivatives also have a large time lag between their publication and the actual occurrence of the economic phenomena they are supposed to measure, and the reported data themselves are subject to substantial post-announcement revisions.

Taking into account these properties of the underlyings, the value of a macroeconomic option before expiration can be represented with the following function:

$$F(E[S_T|I_t], K), \quad (2.2)$$

where $E[S_T|I_t]$ is the expectation of the outcome of the underlying variable conditional on the information available at time t , and K is the strike price. $E[S_T|I_t]$ replaces S_t in a price function of a conventional option, since the underlying variable for a macroeconomic option does not have observable values before expiration date T .² Arguably, $E[S_T|I_t]$ would not change as

² In case of a long-term macroeconomic option, whose life spans several data announcements, the underlying variable may have intermediate observable values before expiration. Nevertheless, not all t would have a corresponding value of the underlying, so the intermediate values would rather influence the value of the option by providing new information on possible future outcomes of the underlying, i.e. through I_t .

often as the prices of conventional underlying assets due to the absence of active trading. For example, most market participants, conceivably, do not update their forecasts of future GDP on a daily basis, so, according to (3.2), their valuations of options on GDP would change less frequently. Similar argument may apply to the forecasts of corporate earnings as well, but stock prices may change on a daily basis due to trading by various groups of market participants, including those guided by other considerations rather than fundamentals.

Moreover, apart from the effect of discounting, the price of a macroeconomic option may not depend directly on time to expiration (hence the absence of T from $F(\bullet)$ above). Conventional option prices typically converge to the options' intrinsic values as the expiration date approaches, even if discount rates are very low. This may not be the case on the markets for macroeconomic options. The difference may be illustrated by comparing the distribution of the terminal value of the underlying assets implied by the option prices before expiration. As Figure 3.1 demonstrates, for conventional options the distribution becomes more 'compact' as time to maturity decreases (panel (a)), while the market for macroeconomic options may not display this pattern (panel (b)). In fact, it can be seen from Fig. 3.1(b) that the shorter-life option prices imply a distribution that is even less peaked than that implied by the longer-life options. This illustrates that macroeconomic options may face relatively high uncertainty regarding the outcome of the underlying variable even when time to maturity is very small. The phenomenon may be explained by the following intuition. The prices of macroeconomic options would depend on the expectations regarding the outcome of the underlying, as expressed in (3.2) and the expectations would, in turn, be conditional on the information available at the time. While more information may be expected to become available as time passes, this information typically arrives to the market randomly. Additionally, macroeconomic options lack the information provided by the prices of the underlying assets in the case of conventional options. Hence, if there is no new information, the price of the option may not change significantly even as expiration approaches.

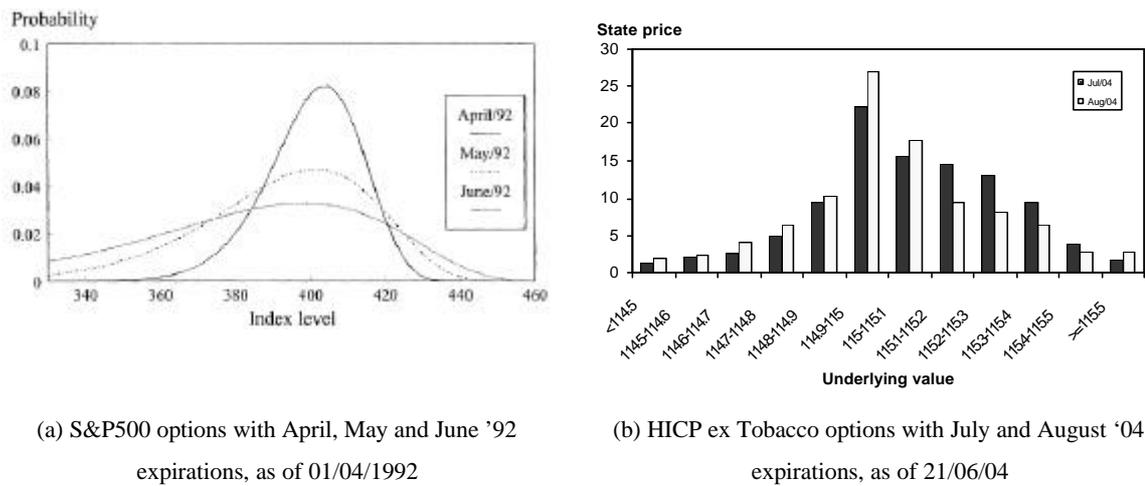


Figure 2.1 Risk-neutral probability density functions implied by option prices

Source: (a) Dumas et al. (1998); (b) Goldman Sachs (<http://www.gs.com/econderivs/>).

The above considerations have important implications for the pricing of macroeconomic options. In particular, they may render the standard option pricing tools such as the Black-Scholes model not applicable for macroeconomic options, which have to be valued, instead, using other tools, such as general equilibrium models.

Another set of problems associated with the use of macroeconomic variables as underlyings for derivatives is the access to information, measurement biases and misreporting.

Conceivably, those with better access to information about the forthcoming release of macroeconomic data would have an unfair advantage on a macroeconomic derivatives market. In essence, the issue, however, is not very different from the one with insider trading in conventional securities, and hence can be reduced with similar regulatory methods. Measurement biases in macroeconomic data that are introduced by statistical and data collection methods, such as sampling errors or interpolation, may be more difficult to eliminate when more accurate methods are impractical or unavailable. It can be argued, though, that as long as information on the possible biases is freely available and, hence, priced in, this problem does not constitute an obstacle to using macroeconomic derivatives. The possibility of data misrepresentation, or the moral hazard problem, can certainly create an issue once macroeconomic derivatives gain significance enough to offer financial rewards for those involved with the determination of the values of macroeconomic indicators. Yet again, misrepresentation occurs with corporate data as well: stock markets have witnessed many episodes of misreporting throughout their history. It always remains a possibility that

investors should be aware of, and that should presumably be reflected in asset prices. To sum up, the data problems with underlying variables for macroeconomic derivatives might cause uncertainty and turbulence on the market, but would not necessarily prevent it from functioning.

2.1.2 *Theoretical role*

Marshall et al. (1992), although having introduced macroeconomic derivatives, did not consider their wider and more fundamental role, which is the subject of this subsection.

In a wide economic perspective, macroeconomic derivatives could be a significant step towards complete risk-sharing. Firstly, macroeconomic derivatives provide a way of trading macroeconomic risks. As stressed by Shiller (1993), these risks are among the most important risks to the incomes of firms and individuals, and there is a need for markets that could help to price and re-distribute these risks. Specifically, Shiller (1993) introduces the idea of establishing a system of large national and international markets for long-term claims on all major aggregate income flows: national incomes, occupational incomes, and service flows from commercial and residential real estate. The creation of markets for a wide array of income flows, according to Shiller, would provide new opportunities for comprehensive risk management, as well as price discovery for major risks that are substantially hidden today. Issuance of instruments with payouts linked to GDP of a country, or to other macroeconomic indicators, could do a great deal to reduce country risk and promote welfare. Ultimately, such instruments should allow individuals to better hedge all types of risks to their living standards.

In a later work (2003), Shiller incorporates the idea of macro markets into his ambitious vision of the ‘new financial order’, a broad vision of risk management in the contemporary economy. Developing the idea further, he argues that macro markets should be created with conceptually simple claims, so that they are easily accessible and reveal information on the current value of a claim on national income. Such claims, represented by ‘macro securities’, should be on the flow of index values extending into indefinite future and thus would resemble stocks. Shiller admits that macro securities are not likely to provide insurance against all specific risks faced by corporations and individuals. The reason is that the economic risks are multiple and difficult to define in detail, if nothing else. Instead, macro securities are supposed to help manage risk measured in terms of large national aggregates,

such as GDP. To a certain extent, these indicators summarize the risk factors affecting an economy and its agents, and hence can be used in risk management of individuals, corporations and even whole countries. Currently, however, there are no markets for claims on national incomes or components thereof, so macroeconomic derivatives in the form of options on economic statistics provide at the moment the only practical tool for the management of macroeconomic risks.

Secondly, macroeconomic derivatives revive an interesting theoretical opportunity within the framework of the intertemporal consumption-based capital asset pricing model (CCAPM) developed by Breeden (1979). This model states a linear relationship between expected real return on assets and expected changes in aggregate real consumption, which can be expressed as

$$E(R_j) = R_f + \beta_{jC} [E(\% \Delta C^*) - R_f], \quad (2.3)$$

where β_{jC} is a ‘real consumption beta’, defined as the local covariance of the real return of the asset j with percentage changes in aggregate real consumption $\% \Delta C^*$, divided by the variance rate of changes in aggregate real consumption (Breeden, 1979)³. Leaving aside the issue of the empirical validity of the CCAPM, it can be seen that in the framework of this model a derivative security on aggregate consumption would play the same role as index derivatives play in the simple CAPM world. Such a security would provide investors with a cost-efficient instrument for participating in the market advances or corrections without having to engage in diversification across all assets, and a tool for portfolio protection. Moreover, a market for options on aggregate consumption would permit to infer the implied distribution of the future aggregate consumption, which, in turn, could be used to find the value of any asset, according to the following general formula:

³ This is a general definition of the CCAPM in a multi-good economy as provided by Breeden (1979), and is the one most useful for this discussion. Commonly, however, the CCAPM is defined in terms of a portfolio most correlated with aggregate consumption, so that the CCAPM equation takes the following form:

$$E(R_j) = R_f + \frac{b_{jc}}{b_{cc}} [E(R_c) - R_f],$$

where β_{cc} is the beta of the portfolio c with respect to the aggregate consumption, β_{jc} is the beta of the asset j with respect to the portfolio c , and R_c is the return on the portfolio c .

$$V_j = \sum_T \sum_{C_T} E[x_T | C_T] P_T(C_T), \quad (2.4)$$

where V_j is the value of asset j at time 0, $E[x_T | C_T]$ are its expected payoffs conditional on the states of aggregate consumption C_T , and $P_T(C_T)$ are the prices of an elementary claims on aggregate consumption, which can be obtained from the prices of options on aggregate consumption (Breedeen and Litzenberger, 1978).

Practically, however, aggregate consumption in the CCAPM is commonly related to private expenditures on (non-durable) goods and services⁴, and a liquid market for derivatives tied to this variable might be not very realistic. Moreover, even if such securities existed, the model itself would have to be adapted to reduce the influence of the econometric problems associated with the underlying variable. The CCAPM prices assets relative to changes in aggregate consumption between two points of time. The national accounts, in contrast, provide data on total expenditures on goods and services over a period of time. This difference can create problems for the CCAPM, since expenditures need not equal consumption, as the goods are not always consumed when they are purchased. Moreover, the reported expenditures are closer to an integral of expenditures over a period of time than to ‘spot’ expenditures. This second problem introduces a ‘summation bias’ (Breedeen et al., 1989). The problem of infrequent reporting of the underlying variable, general to macroeconomic derivatives, would also be relevant in this case.

Finally, macroeconomic derivatives may help improve the sharing of risks across different countries, which is currently incomplete. Shiller (2004) points out that complete risk sharing in a stochastic endowment economy with non-stochastic preferences, according to the CCAPM, would imply that real consumption fluctuations should be perfectly correlated across all individuals in the world. This result follows since with complete risk management any fluctuations in individual endowments are completely pooled, and only world risk remains. However, real consumption changes are not perfectly correlated across countries, as demonstrated by several empirical studies, including Canova and Ravn (1996), Crucini (1999), Lewis (1996), Pakko (1998). Moreover, the correlation of changes in consumption is even lower than the correlation of income changes across countries (Backus et al., 1992).

⁴ For example, Breedeen et al. (1989) used this data in an empirical test of the CCAPM.

Basing on these considerations, the above-mentioned authors arrive to a conclusion that international risk sharing is far from perfect.

An alternative confirmation of this conclusion is provided by Iwata and Wu (2004), who follow an ‘asset-pricing’ approach by comparing marginal utility growth rates extracted from asset returns. This approach is based on a postulate that if macroeconomic risk is fully shared by international investors, the cross-country marginal utility growth rates should have a correlated response to macroeconomic shocks. The study finds that international investors do share the risks associated with exogenous financial market shocks through existing asset markets. However, other macroeconomic risks, such as those related to exogenous shocks to consumption growth, inflation and monetary policies are not fully shared across countries. There is also other evidence that country-specific risks are significant, but currently undiversified. To quantify these risks, defined as country growth uncertainty, Athanasoulis et al. (1999) perform a cross-country regression analysis of economic growth on a set of 49 countries under various horizons using data for 1950-1990. They find that the standard deviation of the growth rate at a 35-year horizon amounts to 33% (16.4% for OECD countries only). Alternatively, they estimate that the probability that the unweighted average GDP per capita of the 7 best performing countries unexpectedly doubles, triples, or quadruples at the 35-year horizon relative to the same measure for the 7 worst performing countries is 99.9%, 89.4% and 29%, respectively.

Other studies find that there are substantial, yet unrealized welfare gains from international risk sharing. For example, Athanasoulis and Shiller (2001), using an intertemporal general equilibrium model, found that arrangements to swap risks between countries would have significant welfare gains. An application of the model to the data on the GDP of G-7 countries in 1950-1992 revealed that creating two optimal risk-sharing contracts among the countries in the study would produce permanent yearly welfare gains of \$400 per capita for nearly every country (almost \$1000 for Japan). Similarly, Athanasoulis and van Wincoop (2000) found that potential welfare gains from risk sharing (measured in permanent percentage increase in expected consumption that leads to an equivalent increase in welfare) are quite sizeable: 6.6% for a 35-year horizon for a set of 49 countries and 1.5% for the same horizon for OECD

countries.⁵ Obviously, when risk management contracts are applied to developing countries, where risks appear to be larger, or extended down to the individual level, the potential welfare gains increase. For example, Athanasoulis and van Wincoop (1997), using historical data from 1870 to 1990, found that the welfare gain from risk sharing could amount to 16.5% for a broad set of 24 countries versus 4.9% for a small set of rich countries.

2.1.3 Risk management applications

Considering the important role of the macroeconomic derivatives and the fundamentality of the economic variables they are associated with, these instruments appear to be potentially useful in a variety of practical applications. One of such promising applications is the use of macroeconomic derivatives by companies, investors and individuals for hedging macroeconomic risks, which is the subject of this subsection.

Risk management is said to be generally more effective when risks can be precisely isolated. Macroeconomic derivatives provide payoffs closely related to specific economic outcomes, helping to insure effectively against the risks associated with these outcomes without any basis risk. Hence, financial contracts on consumer sentiment indices, payrolls, housing starts or GDP growth, especially those that have sufficiently long maturity, open new risk management opportunities for investors, companies, and through them, subsequently, individuals.

It is intuitively clear that companies can use various types of macroeconomic derivatives as a hedge against external economic forces that impact their performance. However, it can be argued that hedging with macroeconomic derivatives is more appropriate for investors than for corporations. According to the Modigliani-Miller paradigm, such hedging activities will not increase the value of the firm. Hence, if companies are acting in the best interests of shareholders, they should not engage in hedging, since their shareholders may be able to manage the risks involved more easily themselves, should they wish so. Furthermore,

⁵ Some previous studies found much lower welfare gains, see van Wincoop (1999) for a review and explanation of the differences. On the other hand, the gains reported above may be even underestimated due to possible secondary-level benefits from risk sharing.

investors may wish to use such protection in terms of their whole portfolio rather than a single share of stock.

Certainly, this argument only holds in the case of symmetric information, i.e. if shareholders have as much information about the risks faced by the company as its management. DeMarzo and Duffie (1991), in fact, demonstrated that if a company has proprietary information on its risk exposure and does not make it available to the shareholders, it may be in the interests of the shareholders that the company engages in financial hedging. This, however, may not be true in the case of macroeconomic risks: conceivably, it should be fairly easy for a shareholder to identify the exposure of the company to a macroeconomic variable, even basing on the information commonly disclosed by corporations. If so, the use of macroeconomic derivatives for hedging may be more appropriate for investors rather than corporations.

Conversely, if the firm does have proprietary information about the source and magnitude of the macroeconomic risks it faces, risk-averse shareholders may benefit from the use of macroeconomic derivatives for hedging these risks. Macroeconomic derivatives would also help to decrease the amount of 'noise' in corporate performance measures and increase their informativeness in respect to the ability of the firm's management (DeMarzo and Duffie, 1995). There are other factors that may make such hedging beneficial in terms of the firm's value: bankruptcy costs and the structure of the corporate tax code (Smith and Stulz, 1985). Additionally, if external financing is more expensive for corporations than internally generated funds, hedging helps to ensure that the company has sufficient internal funds, thereby increasing value (Froot et al., 1993). Finally, if transaction costs are non-trivial, it may be less expensive for a company to execute a hedging transaction than for an individual shareholder.

In such cases, it may be reasonable for a corporation to engage in hedging with the use of, *inter alia*, macroeconomic derivatives, as first proposed by Marshall et al. (1992). Leaving aside the issues of general hedging strategy discussed above, they suggested that macroeconomic swaps and options had the potential to become the first effective tool for

managing business cycle risk.⁶ For companies that face cyclical (or countercyclical) sales, a macro swap would allow to exchange a series of fixed payments for a series of variable payments tied to a macroeconomic variable. If the underlying variable is well-chosen, i.e. it exhibits high correlation with the firm's operating cash flows, such companies would be able to hedge their 'quantity', or macroeconomic risk. For example, an entertainment company might have revenue that is closely correlated to a consumer confidence index. To reduce volatility in its earnings, then, the company could buy a macro swap tied to consumer confidence figures, or perhaps, a macro collar, which would also reduce the cost of hedging.

In a follow-up paper to Marshall et al. (1992), Bansal et al. (1994) studied the potential effectiveness of a hedge that uses a macroeconomic swap on a consumer confidence index. They measured the correlation of the revenues of ten US firms with two different confidence indices. After adjusting for autocorrelation, it was found that the ability of a consumer confidence index to explain revenue volatility differs significantly among the firms in the study: the highest R^2 was 0.5864 and the lowest 0.07. In a second test, Bansal et al. (1995) looked at the correlation of corporate revenues with GDP and showed that derivatives on GDP can provide an excellent hedge. For several of the firms they studied, the coefficients of determination, even after adjusting for autocorrelation, exceeded 0.90. On the basis of these results, Bansal et al. concluded that macroeconomic derivatives have considerable potential to offer a viable tool for hedging business cycle risk for corporations.

Schweimayer (2003) studied the hedging potential of macroeconomic derivatives on the case of a fictional U.S. retail chain. He constructed a synthetic macro index, which consisted of US non-seasonally adjusted monthly retail sales data for two product groups, and used the annual returns on the index as an underlying for a European put option. Assuming that the macro index could explain 90% of the revenue variation of the fictional enterprise, he examined how the payouts of the put options and the cost of hedging influenced the profit of the enterprise under study. The results suggest that the use of macroeconomic put options in a hedging strategy can improve corporate profits, assuming unchanged volatility of the annual earnings.

⁶ Business cycle risk refers to the variation in corporate performance measures due to variations in the general level of economic activity.

Apart from the above results, a variety of other hedging applications for macroeconomic derivatives can be designed. For example, a company, whose inputs are inflation-indexed (e.g. wages and salaries of its workers are tied to a CPI), may find a contract on inflation useful. If the company cannot pass the input price increases on to its customers through retail prices, its earnings may suffer. A long position in inflation futures may help to solve this problem. As another example, a multinational corporation may want to use derivatives on the macroeconomic indicators of the countries where it operates. There is strong evidence that corporate shares are now priced globally, i.e. the market takes into consideration the portfolio of domestic and international value in a company's aggregate value (Diermeier and Solnik, 2001). The greater the proportion of international sales, the greater is the likelihood that the stock is influenced by non-domestic factors. If this is the case, the company might want to hedge some of its international exposures with macroeconomic derivatives (e.g. options on GDP) in order to smooth earnings and increase the share price.⁷

Macroeconomic derivatives can be useful to purely financial market players as well. Economic data releases are among the most anticipated news events in the financial world. Surprises in announcements of such indicators as central bank policy rates, employment figures, consumer price index, and manufacturing indices typically influence the prices of financial assets.⁸ Since the data releases would also determine the payout of macroeconomic derivatives, the latter can be used by traders to hedge their portfolio against adverse price changes due to an outcome of a particular economic variable.

Financial institutions may also find macroeconomic derivatives useful in the following way. Broll et al. (2004) suggest that macroeconomic derivatives are a valuable tool for commercial banks, since they enable lenders to sell the systematic part of the credit risk, according to what capital market theory suggests. Normal credit derivatives do not offer such opportunity. As yet another application, a financial intermediary may want to use inflation-based derivatives in order to hedge its exposures in inflation-linked swaps or inflation-indexed government bonds.

⁷ This suggestion has not been explored thoroughly yet, but such discussion is outside the scope of this paper.

⁸ Evidence for the US bond market provided in Furfine (2001).

Finally, individuals can ultimately benefit from macroeconomic derivatives as well. A worker concerned about a possible future decline in his occupational income might be able to reduce the associated financial consequences by buying a ‘livelihood insurance’, as suggested by Shiller (2003). Such insurance would pay out a regular supplement to the worker’s income if average wages in a particular occupation decline. For occupational insurance policies to become a possibility, insurance companies must be able to hedge the risks they take in writing out retail insurance contracts. They could do this on a market for claims on occupational incomes, the need for which was pointed out already in 1971 by Brainard and Dolbaer. Although short of being such claims, derivatives on average salaries by major occupations would, nevertheless, fulfill the proposed role, i.e. would provide insurance companies with a tool for managing the risks they assume. In this application, though, it is likely that the derivatives traded may need to have longer maturities than common in today’s derivatives markets.

In a similar fashion, a market for contracts on real estate prices could make new insurance products available to individuals, as it would permit insurance companies and speculators to take positions in real estate.⁹ Such products may enjoy a strong demand in many countries, where home equity typically constitutes a large part of an individuals’ net worth. A homeowner, for example, who intends to sell the property at a future date and fears a decline of its price, would benefit from buying protection in the form of an insurance policy, which pays out if the average house prices, or even better, the average house prices in the area, decline by the time of the property sale. An insurance company offering the policies to retail customers would then hedge its risk with derivatives on house prices. Again, such products should have sufficient maturity to be appealing in hedging applications.

2.1.4 Other benefits

Macroeconomic derivatives can certainly have applications beyond hedging. They might even open new opportunities, which have never been considered so far. Although such applications

⁹ Derivatives on real estate prices may be useful to investors in general as well. Such contracts can be used for portfolio diversification, since real estate prices typically behave differently from the stock markets. However, in this role any new derivative products might be overshadowed by REITs, which already enjoy a wide market acceptance.

are outside the main focus of this paper, it is still worth to mention the benefits that macroeconomic derivatives provide for position takers and the market in general.

To speculate on macroeconomic data releases, position takers would typically take major positions in bonds, stocks and currencies. Macroeconomic derivatives provide a more efficient and cost-effective alternative for taking positions on the outcomes of the macroeconomic variables. Firstly, their payouts are by design 100% correlated with the variable, relative to which the position is taken. Secondly, trading in macroeconomic derivatives can be much cheaper than other alternatives, as derivatives in general are characterized by relatively low transaction costs. Thus, for financial firms macroeconomic derivatives provide an efficient vehicle to leverage an in-house economic expertise. They might also be profitably included in the strategies carried out by the hedge funds.¹⁰

Informative function Macroeconomic derivatives have an additional broader benefit: their prices can be used to infer a quantitative estimate of market expectations regarding a particular macroeconomic variable. A clear indication of market expectations would be useful for investment decision-making, since the investment process usually involves judgments about macroeconomic risks. In fact, investors constantly pay attention to the prices of various financial assets in order to determine what potential or expected outcomes are priced-in. However, given the large information flow that influences the market prices of most assets, such estimates are bound to be imprecise. Liquid markets for macroeconomic derivatives would permit to obtain a more accurate and detailed estimate of the market expectations in terms of a certain economic variable. For example, relative option prices can be used to determine implied probabilities of particular market outcomes, so that it would be possible to see not just the implied market forecast, but also the market's view on each outcome. Arguably, the price at the macroeconomic derivatives markets would place more accuracy on economists' forecasts and "consensus numbers would have more meaning" (Chow, 2002). Moreover, the implied forecast of the derivatives market would not be simply a better forecast; rather, it would represent an expression of risk, which would isolate and evaluate quantitatively the portion of the risk imbedded in other markets that are exposed and respond to macroeconomic factors. By supplying an additional, forward-looking measure of market expectations about the outcome of macroeconomic indicators, macroeconomic derivatives

¹⁰ See Tschulk (2004) for an example of using ISM Manufacturing options in a hedge fund strategy.

could contribute to a more efficient incorporation of macroeconomic fundamentals into prices.

2.2 History of macroeconomic derivatives

Macroeconomic derivatives have a history of both failure and success. This section examines unsuccessful attempts to create instruments that may be identified as predecessors of macroeconomic derivatives, analyzes the major obstacles to the introduction of such markets and provides examples of more successful cases of launching macroeconomic derivatives or products that bear some resemblance to them.

2.2.1 Early attempts

Even before macroeconomic derivatives were generally introduced in literature, academics and practitioners had started looking for opportunities to offer means of sharing certain previously untraded risks. The first two variables that naturally came into the focus were inflation and real estate prices. Initially, however, the attempts to develop markets to spread the risks associated with these two variables did not succeed. It may be argued whether contracts on inflation and real estate should be regarded as macroeconomic derivatives or, rather, derivatives on commodities. The underlying assets of these contracts, however, share some features with those of macroeconomic derivatives: they are highly illiquid and their prices are aggregate variables. Hence, the cases of creating markets for inflation and real estate futures are worth discussing here.

Inflation Futures In academic literature, a futures market on inflation was first proposed by Lovell and Vogel (1973). They suggested that commodity futures markets might be naturally complemented by a CPI-futures market, which “would in a variety of ways help reduce the hardship created by uncertain future purchasing power”. The idea received support from the economists, since such market would allow hedging inflation risk directly, rather than through indirect inflation hedges used before (e.g. real estate, stocks, metals, etc.). Existence of CPI futures price would also permit converting nominal amounts into real ones (e.g. in debt contracts). Milton Friedman even suggested in 1986 that CPI futures could become the “largest-volume contract in the country” (cited from Schulz, 2000). However, due in part to

regulatory challenges, a practical experiment was not conducted until 1985. Later, the cause of CPI futures was promoted also by Petzel and Fabozzi (1986).

The earliest attempt to create a functioning inflation futures market belongs to the Coffee, Sugar and Cocoa Exchange (CSCE), now part of New York Board of Trade. Already since 1983 CSCE contemplated establishing a variety of index futures contracts, including contracts on consumer price index, corporate earnings, housing starts and new car sales. Only the futures on the Consumer Price Index for Urban Wage Earners and Clerical Workers (CPI-W) were finally listed for trading in 1985. The settlement was carried out immediately after the data announcement 4 times a year – in January, April, July and October. Unfortunately, the experiment died as a result of lack of interest. In 1985 1,324 contracts were traded, and the next year the number increased to 8,776. In 1987, however, the market broke down, with only two contracts traded during the year. As a result, the CPI-W futures were subsequently de-listed.

According to practitioners, the main factor that contributed to the failure of this innovative instrument is that it appeared to be very much ahead of its time – at that moment even inflation-indexed securities were yet to be introduced. Moreover, no stable pricing relationship existed with other instruments. Finally, CPI futures appeared less appealing than commodities, such as gold (Srinivasan, 2004).

Another explanation for the lack of interest is that the new market became a victim of the relatively stable prices. Indeed, the decline in oil prices significantly reduced the price volatility. An established market would have probably survived such a period, but the CPI-W futures market was not yet liquid enough, and the decline in volatility prevented the contract from developing (Shiller, 1993).

In addition, Schulz (2000) provides the following explanations for the failure of the CPI futures market:

- *Alternative strategies*: there existed other strategies to hedge against real income risk.
- *Design flaws*: the volume of the CPI futures contract was too large for the average potential user; the time horizon of max. 3 years was too short.

- *Psychological barriers*: most people were still inexperienced with indexed financial instruments.

To sum up, it appears that this early attempt to establish a macro market failed not because of its being unnecessary, but rather as an accident of history. In fact, Schulz (2000) tried to explore whether there are fundamental theoretical reasons why a CPI futures market could not succeed and failed to identify any.

A market similar to a futures market for the consumer price index was also established in 1987 in Brazil. The Brazilian futures were technically futures on the payouts of government obligations, but since their payout was indexed to the monthly CPI, the market practically represented a futures market on CPI itself. The experiment was ultimately terminated by the Brazilian government, which feared that the futures contracts on CPI promoted inflation, as suggested by a popular theory of the time (Shiller, 1993).

In June 1997 the Chicago Board of Trade attempted to trade futures on Treasury Inflation Protected Securities (TIPS). While those contracts were not directly indexed on inflation (CPI), a price relationship with TIPS implied a de facto inflation futures contract. Only 22 contracts were traded, all in 1997. Subsequently, the TIPS futures were de-listed. Again, the new contract appeared ahead of its time: the TIPS were only at its infancy. The inaugural TIPS issue was auctioned barely five months prior to the introduction of the futures, and the only outstanding issue was the ten-year TIPS. The market had yet limited participation, and the new futures effectively competed with TIPS for liquidity. Moreover, there was still uncertainty over fate of the TIPS program itself (Srinivasan, 2004).

Real Estate Futures Some researchers also proposed a futures market for real estate (Miller, 1989 and Gemmil, 1990). In 1991, following these proposals, the London Futures and Options Exchange (London Fox) made an attempt to establish such a futures market, in order to make possible hedging, arbitrage and price discovery in real estate. The futures contracts were introduced on both single-family homes and commercial real estate. The residential contract was settled on a hedonic price index estimated on market prices of individual homes. The commercial contract settled on an index of appraised value, provided by Nationwide Anglia Building Society (NAHP index). Unfortunately, the contract traded for less than a year, since the trading volume was very low. The initiative also suffered from allegations that

the exchange tried to inflate the trading volume by reporting false trades. When the fraud was reported in the press, the futures market was closed.

Again, in this case it appears that the collapse of the new market was caused by the alleged deceptive practices of the exchange's management, but not by an aversion of market participants. The real estate futures did not trade long enough for the market participants to get into the market. Besides, at time of the launch the real estate market in the UK had a low turnover, prices were steadily falling, and there was little interest in this market in general, not to mention innovations. Patel (1994), in addition to the general problem of the absence of an arbitrage-pricing mechanism mentioned before, sees another reason for failure in the construction of NAHP index, which showed significant lag dependence over time. Consequently, the futures contract settling on this index did not provide an economic benefit from hedging. Furthermore, due to high transaction costs and time lags involved in operations with real estate, potential hedgers, according to Patel, would likely also bear time basis risk.

A futures market in real estate has also been advocated by Case, Shiller and Weiss since 1990.¹¹ Their appeal was taken up by the Chicago Board of Trade, which in 1993 issued a press release stating that the Exchange had tentative plans to introduce futures on single-family homes by city. The plans were abandoned, however, since exchange officials were discouraged by a survey that indicated only short interest. As another example, Enron Corporation, before it went bankrupt in 2001, also had had plans for developing a futures market for commercial real estate in the United States.

2.2.2 *More successful cases*

Despite of the failures described so far, macroeconomic derivatives found their way into existence, albeit sometimes only as embedded clauses. The growing anxiety about the riskiness of economic life might have pushed practitioners to seek opportunities to offer their clients new risk-management products. In addition, the increasing potency of information technology facilitated the development of new products in the field of derivatives. Although most of the cases in this subsection fall short of being full-scale markets for macroeconomic

¹¹ See, for example, Case et al. (1993).

derivatives, they nevertheless demonstrate the path of innovation and the reaction of the market. The cases are reviewed in chronological order.

First GDP-linked Sovereign Bonds Costa Rican debt was, perhaps, the first to carry value recovery payments pegged to the country's GDP, which in effect represented a (macroeconomic) warrant attached to the bonds. The May 1990 Brady Plan for Costa Rica contained a recapture clause conditional upon GDP, which gave the bond holders the right to receive higher interest payments on certain bonds if GDP exceeded 120% of the 1989 level in real terms. The threshold for the payments was exceeded in 1993. Facing the need to make additional payments, Costa Rica subsequently retired early a portion of the two of its Brady issues that were linked to GDP. Curiously, the existence of the warrant went largely unnoticed until a Bear Stearns analyst wrote about it in 1994. Moreover, Costa Rica appeared unaware that it needed to make the payments until Bear Stearns showed the bond trustee that Costa Rican GDP had reached the required targets (Bary, 1996).

Bulgarian Discount Bonds In 1994, Citibank N.A., an investment bank, engineered a loan for Bulgaria with an interest rate tied to the country's economic growth. Within a debt restructuring agreement with the London Club of private creditors, Bulgaria issued US\$1,865 million worth of Discount Bonds (so-called DISCs) maturing in 2024 with an innovative feature: Additional Interest Payments (AIPs). These AIPs were not warrants, detachable or otherwise, but they were equivalent to them in nature to an macroeconomic option. The AIP clause of the Bulgarian bond contracts stated an obligation of a supplemental interest payment for each year in which (1) Bulgaria's gross domestic product surpassed 125% of its 1993 level, and (2) there was a year-to-year increase in GDP (the year in which the threshold was reached was exempted from AIPs). For the years matching the two criteria, the semi-annual interest supplement was defined as one-half of that year's GDP growth, with the actual payments scheduled to occur as soon as practically possible and to coincide with regular interest payment dates.

Given the sharp decline of the Bulgarian GDP in the early 90s, the AIPs might be considered as a rather generous offer to the creditors during the restructuring talks.¹² However, the clause

¹² It may be also conjectured that the officials guessed that in times of good performance the country might be able to redeem early a significant portion of debt, as the bond was callable from July 2004, thus avoiding to pay

worked well for the issuer, since over the period when the bonds were outstanding the growth of the Bulgarian economy was relatively weak. AIPs effectively served for managing the economic risk for Bulgaria, reducing the cost of borrowing for the country in times of inferior performance of the economy. As to the benefit to the investors, an analyst suggested that “the Discount bonds may be attractive to investors most intrigued by the prospect of an uncorrelated emerging market asset possibly paying a GDP-linked bonus” (Segal, 2004). These expectations were not fulfilled, since no bonus was ever paid, as explained below.

There were some practical issues with the design of the Bulgarian Discount Bonds. Given the normal technical lags and delays in data collection and calculation, as well as the coupon schedule, the supplemental payments could occur at the earliest seven months after the end of the calendar year of record. Potentially the lag could be as much as four years, which might be rather uncomfortable for the investors. Another serious problem was that the GDP indicator had not been clearly defined. According to the documentation, the figure for gross domestic product was to be taken from the publication of “the World Tables of the World Bank.” The publication itself, though, contained several different aggregates – in constant and current units, in US dollars and local currency. According to calculations performed by analysts before the bond redemption in 2004, interest arrears would have amounted to US\$228 million if GDP had been calculated in local currency at current prices and US\$51 million if it had been calculated in dollars at current prices. At constant dollar prices the GDP threshold would have been crossed in 2003, and at constant leva prices it would have been exceeded only in 2005 (Batchelor, 2004). The financial community, apparently, assumed that the measure of GDP to be used was the one at constant prices in local currency, so no AIPs were actually executed before the outstanding amount of the issue was called in July 2004.

Bosnian Warrants The Bulgarian example was taken up by Bosnia and Herzegovina. In 1997 commercial creditors agreed to write off all overdue interest and restructured the principal of the Bosnian debt owed to them into DM262 million 20-year discount bonds. The issue is divided into two parts. The second, or B, portion of the bonds is, in effect, a warrant on future economic performance and will be triggered if Bosnian gross domestic product per capita exceeds US\$2,800 for two consecutive years before 2017. The reference value is

the AIPs on the repurchased bonds (Segal, 2004). In fact, parts of the issue were bought back by Bulgaria before the first call date and the rest called in July 2004.

considered GDP per capita in U.S. dollar terms measured in 1997 prices. The possibility of reaching the threshold was determined as extremely unlikely at the time of the restructuring agreement, as the GDP per capita at the end of 1997 was at only US\$615, according to European Bank for Reconstruction and Development estimates (Chance, 2002). However, the probability of reaching the threshold has increased: in 2003 Bosnian GDP per capita reached US\$1,822, while the threshold, adjusted for inflation, increased to about US\$3,000 (IMF, 2004a). For the purposes of this paper, it is also important to note that the Bosnia B warrant is actually trading *separately* of the A portion.

Michelin The GDP-indexing features also appeared in corporate financing as well. In 2000 Swiss Re New Markets and Société Générale arranged for Compagnie Financière Michelin (CFM), the Switzerland-based financial and holding arm of the Michelin tire group, a \$1 billion 12-year committed subordinated loan facility. The deal was not only the first combined bank and insurance capital facility, but also included an innovative feature. Under the terms of the transaction, CFM is guaranteed access to a bank credit facility for five years, i.e. up to 2005, and the option to draw under certain conditions on an insurance facility for five years. The trigger event for the latter is a decline in the combined average annual GDP growth rate in Michelin's principal markets (the euro zone and the US) below a certain level. This level is set at 1.5% in the first three years, and 2% in the last two years of the five-year option. The insurance trigger was structured into the deal because of the consideration that Michelin's revenues are highly correlated to economic growth in its main markets, so that if GDP in these areas fell, the facility could provide an opportunity for restructuring (Schenk, 2000).

Positions on Real Estate In London, two financial betting houses, City Index and IG Index, offered contracts for taking positions on house prices. City Index launched its Property Futures as early as October 2001. These futures provided the opportunity to take positions on variation in house prices, through contracts on the average house price for several regions, as well on certain specific property types for several London Boroughs. The Property Futures were based on the Residential Property Price Report published quarterly by HM Land Registry, which is based on actual house sales, as opposed to other indices that rely on real estate agent valuations and forecasts. The City Index's property futures, consequently, had maturities of 3 months, and were criticized for being too short-dated for many potential

homebuyers.¹³ However, the market appeared to be rather successful in the first year of its introduction, with open interest amounting to more than £2 million.¹⁴ At the moment, City Index does not enter any more in contracts on housing prices for undisclosed reasons.

The other company, IG Index, started offering similar in nature Contracts for Difference (CFDs)¹⁵ on housing prices in 2002. The House Price CFDs allowed to take positions on the average house price for the overall UK market, for up to four quarters forward, as well as for twelve UK regions, including London, the most volatile and the most publicized housing market in the country. All contracts were settled against the Halifax House Price Survey released by HBOS. For the first 5 months after introduction, IG Index sold £20m worth of House Price contracts, with the majority of the buyers being hedging homeowners. IG Index had no other markets in which to hedge house price risk, so the imbalance of long and short interest forced one-year contracts to trade at a 10% to 15% discount to fair value (Polyn, 2002). Currently, CFDs are offered through a subsidiary, IG Markets, but the company does not take trades on House Price CFDs, since its books are full. There is not a lot of movement in this sector, but the interest on the part of investors remains strong.¹⁶

New Singapore Shares A rather close parallel to macro securities suggested by Shiller (1998) has been introduced in Singapore. Starting from November 2001, the Singaporean Government issued the so-called New Singapore Shares (NSS) to the total amount of S\$2.7

¹³ “IC Asset Allocation - The Magic Rule Of Investing - Some People Might Need To Make Only One Investment Decision In Their Lifetime. Chris Dillow Explains”, *Investors Chronicle*, 18/01/2002

¹⁴ “£2 million bet on house price collapse”, <http://www.themovechannel.com/sitefeatures/news/2002-july/5d.asp>, 05/07/2002

¹⁵ House Price CFDs were cash-settled futures contracts that gave investors exposure to changes in the housing market without all the effort of buying and selling property. They were leveraged products in the sense that they did not require putting up the full underlying contract value, with a low minimum margin requirement. CFDs were rather versatile: it was still possible to take long and short positions, so CFDs provided a convenient and inexpensive method of shorting the underlying index. For example, a short position in a House Price CFD might be used for hedging against the risk of a property portfolio dropping in value, whereas a long position could provide a protection from being priced out of the property market during the time of absence. The CFD markets in general also have some additional advantages, such an exemption from stamp duty (a levy imposed on the buyers of registered securities in the UK), risk protection (closure of positions at specified stop levels), very low limits on minimum trade sizes, and immediate dealing.

¹⁶ Based on information provided by IG Markets in late January 2005.

billion and distributed them to 2.04 million eligible citizens, who received between S\$200 and S\$1,700 worth of NSS. The shares have a guaranteed minimum dividend rate of 3% per annum. Every year NSS also pay an extra dividend equal to the real GDP growth rate (if positive) of the previous calendar year. On 1 March 2007, all outstanding shares will be automatically exchanged for cash at \$1 each, but the holders can also redeem them before maturity.

The NSS's were distributed to the lower-income citizens (mostly the elderly and less educated) in an attempt to reduce income disparities, but the GDP option was supposedly designed to give these citizens a feeling of participation in the economic success, if any, thereby encouraging greater commitment and involvement in the local economy. While from this social security point of view the scheme may be considered very appealing, it appears to be inferior from a risk-management perspective. The NSS are not tradable and thus cannot be sold to foreigners, so the aggregate macroeconomic risk remains undiversified. Furthermore, the NSS's do not reveal any price on a claim on national income.

To help Singaporeans cope with the Goods and Services Tax (GST) increase between January 2003 and January 2004, the Government also issued Economic Restructuring Shares (ERS). The ERS is part of an offset package that, according to the Singaporean Government, is enough to cover the increase in GST that most households will have to pay for at least 5 years. The first lot of ERS was issued in early 2003, the second – in early 2004 and the third is to be issued in early 2005. ERS earn tax-free dividends each year in the form of bonus shares, payable every year on March 1st from 2004 to 2008. The rate is similar to that of the NSS's: a guaranteed minimum of 3% + real GDP growth rate of the previous year.

2.2.3 Major practical obstacles

The history reviewed in the preceding subsections highlights some of the barriers that hindered the development of macroeconomic derivative markets. Besides the theoretical issues outlined in the beginning of the chapter, the reviewed cases reveal the practical and institutional issues facing macroeconomic derivatives. In addition, Borensztein and Mauro (2004) and Shiller (2003, 2004) suggested a number of other market failures that may hinder beneficial financial innovation in general, and may be also relevant for the case of macroeconomic derivatives, even though it is not always directly evident from the cases

above. The list of possible challenges to the introduction of macroeconomic derivatives includes the following:

- **Liquidity:** A major problem encountered in introducing macroeconomic derivatives to the market was the one of achieving sufficient liquidity. Practically, it was very difficult to build volume. New and/or complex instruments tend to be illiquid, and pricing them involves computational costs, so it is easy to understand why investors generally tend to react not very enthusiastically to financial innovation ideas. For a new market to be successful, a certain ‘critical mass’ must be achieved. It requires a concerted effort, which would help guarantee market liquidity and spread computational costs over a large market capitalization for the new instruments.
- **Measurement and Misrepresentation Problems:** How well an index or an indicator tracks the economic phenomena it is supposed to measure is often debatable. In fact, measuring macroeconomic variables involves some subjectivity. At any given time there may exist two or more different estimates for similar variables. Another problem is that in certain cases governments may have a substantial degree of control over macroeconomic statistics, even though statistical agencies in many countries are independent. This is especially a problem for GDP-linked securities: when repayments are linked to economic indicators produced by the debtor country, the authorities might be tempted to tamper with the presentation of those indicators. Moreover, even for advanced countries, initial data releases may be subject to substantial revisions. Investors might perceive potential data revisions as an additional unwelcome source of uncertainty. Finally, economic data typically becomes available with significant lags, which also may be uncomfortable for investors.
- **Suitability of Indices:** Another problem highlighted by the reviewed cases is that of the appropriateness of the economic data and indices used to settle macroeconomic derivatives. For a functioning derivatives market, it is critical that the indices represent the value associated with a standard claim on future income or services. The standardization in indices used in contract settlement is, in fact, essential to the liquidity in the new derivative markets. In this sense it would be reasonable to use widely available economic indicators and indices for contract settlement. The available historical data and public familiarity with such indicators may, indeed, favor the acceptance of the new derivatives. However, there is

a potential pitfall in existing variables and indices: they may be not directly suitable for risk-management purposes, and in this case the basis risk will not be completely eliminated. To provide a simple example, the modern technique used to construct a consumer price index may make it sufficiently representative of the price dynamics in an economy. However, for a single agent, e.g. an enterprise, the price dynamics of its inputs can be rather different from that of the widely accepted CPI measure. A derivative settled on this basis, thus, will be not very useful for the hedging needs of this particular agent. In a similar argument, Shiller (2003) contends that new, special indices should be designed for using with macroeconomic derivatives, so that these contracts are settled based on a variable that closely reflects the exposure being hedged.

- **Product Uncertainty:** It appears that market participants do need some time to get familiar with new products. When a new financial instrument is introduced, investors may be uncertain about exactly what they are buying. Therefore, they will demand a premium, which, in turn, may deter issuers from issuing the new instrument in the first place. It appears that investors need to be educated and informed about the characteristics and uses of the new products, but in most cases described above an extensive information campaign was absent.
- **Reluctance of Market Makers:** It is often said that futures markets succeed only if there are professional dealers willing to stock an inventory in the security traded. The financial intermediaries, however, have been reluctant to make markets for macroeconomic derivatives since the return on risk capital for making markets has been insufficient, while the risk that would have to be assumed by the financial institution might be significant (GS/DB, 2002). The absence of a tradable underlying asset also makes it difficult for the market makers to cover their positions. Another related obstacle might lie in the highly competitive structure of financial markets. In introducing a new type of financial instrument, a private financial institution incurs 'first-mover' costs. However, it may be unable to maintain a monopoly over the new market: patents are rarely (though increasingly) used for financial instruments and imitation is quite easy. Thus, the institution may be unable to rip the benefits of its innovation, which reduces the incentive to develop the instrument in the first place, even though the social benefit of the innovation may be high.

- **Coordination Problems:** While investors need time to learn to price the new financial instruments, they may also need a large number of issuers that offer the new instruments in order to be able to diversify risk. An individual issuer may teach investors to price its own instrument and thus help them to learn to price those issued by others, but an issuer is unlikely to take this into account *ex ante*. Nor a private issuer, unless it is a not-for-profit organization, will consider the social benefit of the new risk-sharing opportunities provided by the new instrument. Thus, when all other issuers are offering standard instruments, each individual issuer is likely to continue using standard securities.
- **Institutional Rigidity:** An explanation related to the previous one is offered by Shiller (1993). He argues that innovation in derivatives markets has been held back by the institutional rigidity that favors maintaining status quo. Insurance, banks, and investment companies may be slow to introduce new products because of separation of control over their actions. There are three groups that guide the operations of the organization: its management, clients, and government regulators. The management is responsible for the day-to-day business, but influenced by the two other groups. If the clients themselves are again companies, governments or even the general public, it is sometimes difficult to explain the qualities of new or improved instruments to non-professionals. It also may take considerable time to convince regulators of the importance of some financial innovations.
- **Need for Standardization:** A liquid secondary market where investors can easily diversify their portfolio requires that the traded instruments have identical features for all issuers. Moreover, for contingent claims it is crucial to have unambiguous and verifiable standards that describe the event on which the claim is contingent. The standardization process for macroeconomic derivatives, however, has not yet begun, and in some cases the design of new securities leaves considerable room for interpretation of trigger events (e.g. in the early GDP-linked securities).

The importance of the described obstacles for the case of GDP-linked securities was assessed by IMF researchers through a systematic survey of market participants conducted in collaboration with the Emerging Markets Traders Association (EMTA) and the Emerging Markets Creditors Association (EMCA). Respondents of the survey identified liquidity and the potential for mismeasurement of GDP as the key obstacles to the use of growth-linked instruments (IMF, 2004b).

To sum up, the review of the historical experience leads to a conclusion that there are substantial obstacles to the introduction of macroeconomic derivatives. However, an absence of a financial instrument says little – positive or negative – about its desirability and feasibility. Due to coordination and design issues financial innovation in practice appears to be a rather unsystematic process. New financial instruments do not seem to result from a systematic search for optimal risk sharing, or a gradual evolution leading to superior forms of finance. Instead, failures or successes of new instruments appear to be accidents of history, due to a particular combination of circumstances.

The situation with financial innovation, and with macroeconomic derivatives in particular, might be similar to that of multiple equilibria. Theoretically, macroeconomic derivatives seem useful, and the reviewed history may indicate that the market is potentially interested in them. However, a move to the new equilibrium with these new instruments may require additional experimentation, efforts to find the precise financial structure that will perform well, and efforts to educate the potential clients about the new risk management tool.¹⁷ In many cases, financial innovation also requires strong intervention on the part of policy-makers and academics in order to make a variety of changes needed to make the innovation work, or commitment by individuals willing to take unusually large risks. Often-quoted examples of such official or individual involvement include the role of the government in establishing the market for mortgage-backed securities in the United States, and the personal role of Michael Milken in creating the market for junk bonds.

2.3 Current state

To extend further the analysis of the cases of financial innovation involving macroeconomic derivatives – or similar instruments – of various characteristics and success, this section proceeds to describe currently operating markets for macroeconomic derivatives, which may

¹⁷ Bettzüge and Hens (2001), using an evolutionary finance approach, also find theoretical support to the empirical observations that the success of a financial innovation, as a mutation, depends on a sufficiently high trading volume, marketing, and new and differentiated hedging opportunities.

have managed to overcome some of the challenges described above. The most known of these cases is the Economic Derivatives market created by Goldman Sachs and Deutsche Bank, which trades options and forwards on economic data releases. Some of the newer developments are also reviewed.

2.3.1 Economic Derivatives

A first report mentioning a new market for the previously untraded macroeconomic risks appeared in October 2001 in the *Futures and Options Week*¹⁸. The report informed that two banks, JP Morgan and Deutsche Bank were working on creating a market for derivatives on economic data releases in the US and Europe. The author suggested an enormous potential of the new derivatives: "The use of these products could expand in ways that can't be predicted right now" (quoted from Schweimeyer, 2003). The market was indeed started a year later by Deutsche Bank in cooperation with Goldman Sachs, as JP Morgan backed away from the project. The new products offered by the consortium were called "Economic Derivatives".

The Economic Derivatives market allows its participants to buy and sell call and put options, both vanilla and digital, as well as forward contracts, on a certain forthcoming economic release. To satisfy most of the participants' demand, multiple strike prices are offered, e.g. in the range of 2 to 2.5 standard deviation of the potential outcomes of the data release.

Derivatives are bought and sold in universal Dutch auctions¹⁹ held on specific dates prior to the data release, and then settled according to the release. Thus, the Economic Derivatives market is not an exchange-like market – it is rather an auction market for over-the-counter (OTC) derivatives, which is only open during specific periods of time (usually one hour). Moreover, trades are booked and settled using standard documentation for OTC derivatives, which may have helped to foster acceptance of the new derivatives among the financial community.

¹⁸ See Topping (2001).

¹⁹ "Dutch auction" here means a uniform-price auction, whereby securities are allocated to the highest bidders until the total amount of securities on offer is covered. All successful bidders pay the price quoted by the lowest bidder (the clearing price).

Box 2.1 An Auction Example**Terms:**

Event:	ISM Manufacturing PMI
Release Date:	1 st February 2005
Auction Date:	1 st February 2005
Auction Time:	08:00-09:00 NY time
Strikes:	53 to 61 in 0.5 increments
Tick size:	Percentage points

Sample order:

Order type:	Buy vanilla call
Strike price:	55
Order size:	\$50,000/tick
Limit price:	\$2

Results:

Implied market forecast:	56.793
Price of a vanilla call with strike 55	\$1.98643
Settlement value:	56.4

If a participant enters an order to buy a call option with a strike price of 55 and a limit price of \$2, his/her order will be fully filled, and the participant pays $50,000 \times 1.98643 = 99,321.5$ in premium. At expiration, the option pays $50,000 \times [56.4 - 55] \times 100 = 7,000,000$.

Source: <http://www.gs.com/econderivs/>, Yahoo Briefing Economic Calendar (<http://biz.yahoo.com/c/e.html>)

Three basic types of instruments are offered on the Economic Derivatives market, with payoff profiles in conformity with market conventions (payoffs are illustrated in Fig. 2.2):

- *Range forwards*: essentially single-strike risk reversals, in which the strike is the implied market forecast; have zero upfront premium and provide a simple way to go short or long in an economic data release; payouts are capped at the lowest and highest strike boundaries;
- *Vanilla options*: calls pay a fixed amount per tick that the outcome is above strike, puts pay a fixed amount per tick that the outcome is below strike; call options are capped at the highest strike available (puts at the lowest); vanilla spread options with caps closer to the strike are also available;
- *Digital (binary) options*: calls pay a fixed amount if the outcome is equal to or above strike, puts pay a fixed amount if the outcome is below strike; digital ranges are also available.

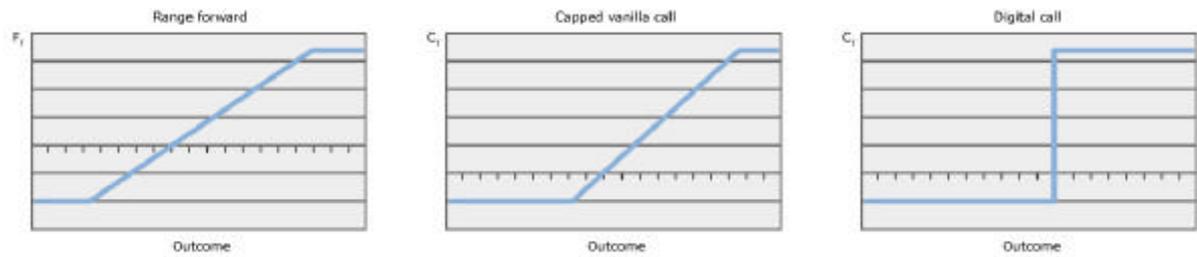


Figure 2.2 Basic types of Economic Derivatives

Source: <http://www.gs.com/econderivs/>

The first auctions took place in US non-farm payrolls. Soon after, several new releases were added – monthly manufacturing figures from the Institute of Supply Management, and US retail sales (excluding automobiles)²⁰. The market received the new derivatives quite well: the interest exceeded the expectations of the launching consortium, with payroll being the most liquid section (Cass, 2003).

In May 2003, following requests from European clients interested in hedging risk for both inflation swaps and inflation-indexed government bonds, the sponsoring banks started offering one- and three-month options on Eurozone harmonized index of consumer prices (excluding tobacco)²¹. In February 2004 auctions on US Initial Unemployment Claims were launched, reflecting a demand from fixed income traders, who generally pay close attention to the labor market. In January 2005 the set of Economic Derivatives was expanded to include U.S. gross domestic product (quarterly release). Additionally, in February 2005 the consortium launched auctions for derivatives on the U.S. international trade balance report (monthly release). Table 2.2 summarizes the economic data releases currently included in the set of auctions. In future, the sponsoring banks plan to introduce auctions on a US inflation measure, as well as to extend the family of Economic Derivatives to include more non-US measures, including GDP figures.

²⁰ The Retail Sales auctions were discontinued in February 2004 and reinstated in September of the same year.

²¹ Later only 1- and 2-month options.

Table 2.2 Statistics currently included in the Economic Derivatives auctions

Statistic	Reporting Agency	Frequency of Release	Frequency of Auctions
US Nonfarm Payroll	Bureau of Labor Statistics	monthly	2 every month (1 day before & on the day of release)
US Manufacturing PMI	Institute of Supply Management	monthly	monthly (on the day of the release)
US Retail Sales (excl. autos)	Census Bureau of the Department of Commerce	monthly	monthly (on the day of the release)
Eurozone HICP (excl. tobacco)	European Central Bank	monthly	monthly (1 & 2 months before the release)
US Initial Unemployment Claims	Employment & Training Administration, Department of Labor	weekly	weekly (on the day of the release)
US GDP	Census Bureau of the Department of Commerce	quarterly	monthly (on the days of advance, preliminary & actual release)
US International Trade Balance	Census Bureau and the Bureau of Economic Analysis of the Department of Commerce	monthly	monthly (on the day of the release)

One of the main concerns expressed by the potential users before economic derivatives were launched had been that of liquidity.²² The fact that the new market was developed in a consortium, thus, might have been crucial to its success: the two large financial institutions brought together their respective fixed income, equity and foreign exchange clients in order to generate liquidity, rather than focusing on economic statistics in separate regions. All orders regardless of the source are combined into one pool during specific, discrete auction periods, thereby building liquidity (see Fig. 2.3). Moreover, the two banks showed considerable commitment to launching the new derivatives thoroughly by creating market awareness and educating the clients about the new product. In May 2003 ICAP, the world's largest inter-dealer broker, began offering economic derivatives to its clients, introducing Economic Derivatives to the interbank market as well. As a result, the Economic Derivatives market has

²² The other concern is the adequacy of underlying data. This concern has not been explicitly addressed by the sponsoring banks. See subsection 3.1.4 for a discussion for the case of GDP derivatives.

consistently tripled year-over-year since inception²³ and currently is the most liquid market for direct trading of economic data releases.

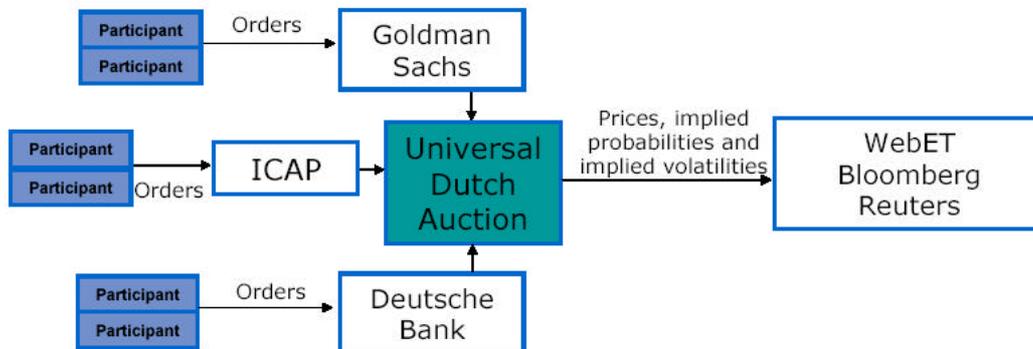


Figure 2.3 Economic Derivatives liquidity pool

Source: GS/DB, 2004

Parimutuel System An even more critical element of the Economic Derivatives market is the Parimutuel Digital Call Auction (PDCA) technology, on which it is based on. The PDCA technology (dubbed as the “universal Dutch auction” by Goldman Sachs) was developed by US financial technology firm Longitude, Inc., which introduced parimutuel principles to the derivatives market.²⁴

Parimutuel systems are extensively used in wagering on sports events. In a parimutuel mechanism, customers typically place bets during a specific period before the event. After the betting period ends, customers receive the odds on their wager, which are then used to determine the payout to successful bettors after the event has ended. The intermediary collecting the wagers does not take any risk associated with the outcome of the event. The odds are determined such that the total premium paid equals the payouts – effectively, the losing wagers fund all the winning wagers. Thus, the parimutuel system can be described as “self-hedging”.

The PDCA technology applies the parimutuel mechanism to financial markets, but with several necessary modifications, listed below.

²³ “Goldman, et al Launch Auctions”, *Wall Street Letter*, 28/01/05

²⁴ Besides Economic Derivatives, the PDCA technology was used to create mortgage prepayment derivatives, launched in June 2003 by Goldman Sachs in partnership with ICAP, and options on crude oil inventory statistics, launched by the New York Mercantile Exchange, Goldman Sachs and ICAP in October 2004.

- The parimutuel system, which typically allows trading of only binary options, was extended in the PDCA to include also vanilla call and put options and spreads.
- Customers in a PDCA auction submit limit orders, while in a conventional wagering system customers usually do not have any control over the price they pay for claims.
- The PDCA technology permits participants to submit both buy and sell orders, as opposed to only buy orders in parimutuel wagering systems.
- Instead of specifying a fixed amount of premium to pay, with subsequent payout subject to uncertainty, in a PDCA auction participants request a specific number of contracts, and the price they obtain remains uncertain until the end of the auction.

A critical feature of PDCA auctions is that they effectively optimize liquidity. Each order at the auction is executed in combination with parts of other executed orders – the so-called “many-to-many matching”. It cancels the need for finding discrete order matches and removes the constraints imposed by the traditional market-making system. Traditionally, derivatives markets rely on standard order-matching techniques. For each buy order the market-maker searches for a corresponding sell order of the same type of instrument, with the same price and quantity. In case of a large order flow, liquidity is usually sufficient and transactions are frequent. Otherwise, traditional market-making may involve order mismatches. A financial intermediary typically allocates capital for such mismatches, and attempts to use the underlying instrument to facilitate order matches in the derivatives market for its customers. However, when there is no tradable underlying, order matching becomes difficult.

The PDCA technology eliminates the requirement for making markets. It aggregates liquidity across different instruments and strikes into a single pool. For a transaction to be executed, a discrete order match is not required. Because orders are matched “many-to-many”, each order can provide liquidity for other orders, even though the latter might be for different instruments. A PDCA auction is able to operate even with option buyers only. A tradable underlying instrument is not required to create a liquid derivatives market. Moreover, at a PDCA auction the prices are based on relative supply and demand of all participants and are determined so that as much order interest is cleared as possible.

Parimutuel pricing also helps to reduce the product uncertainty problem. As mentioned in subsection 2.2.3, investors are often reluctant to get involved in a new market until they develop an understanding of fair pricing and liquidity. In a PDCA auction prices are market-driven and determined by customer participation, rather than by some model or subjective assessment of the price of risk. Customers receive a price for a derivative based on underlying risk that reflects the consensus view of all participants in the auction. Prices in the auction are based on commitment of capital by all participants and are not set by an individual market-maker, so that a fair and level playing field is created. Moreover, the PDCA auctions are very transparent: indicative prices, implied volatilities and probabilities are broadcast in real time during the auction period.

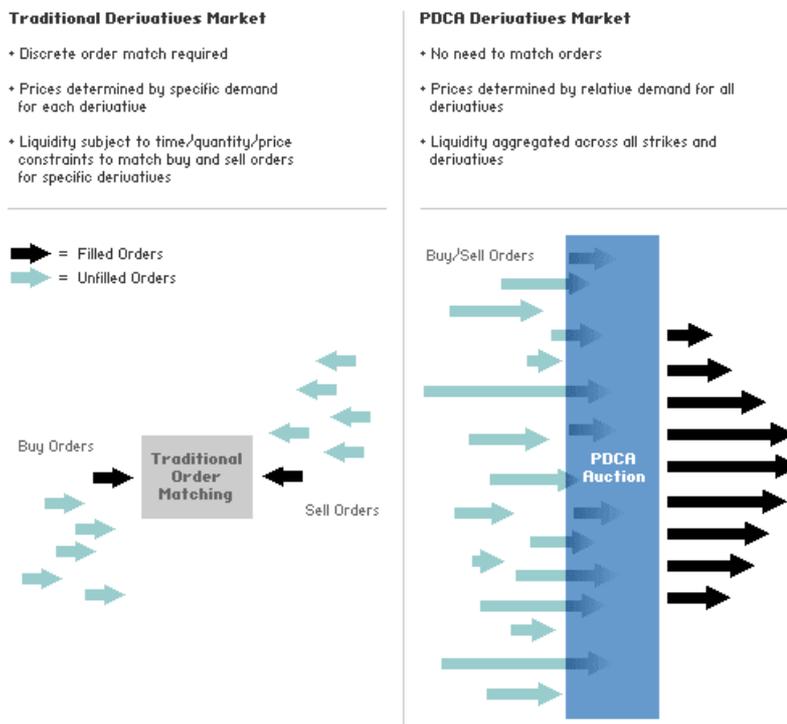


Figure 2.4 Comparison of traditional order matching and PDCA auction

Source: http://www.longitude.com/html/pdca_technology.html

The price tends to improve automatically with new orders: most orders have a positive effect on the pricing of other orders in the auction. If the demand for a particular contract increases, auction participants bid up its price, and the other derivatives being auctioned become relatively cheaper. For example, suppose an order that has a view on the data release below the current market expected value is entered in the system. This order makes other orders at the center of the implied distribution relatively cheaper, and those at the left tail – relatively

more expensive (Fig. 2.5). This order improves the price of the orders with dissimilar views (acting as supply) and raises the price of the orders with similar views (acting as demand). New participants entering the auction continuously influence the order in a positive way, and at the end of the auction it gets filled at a better price than initially.

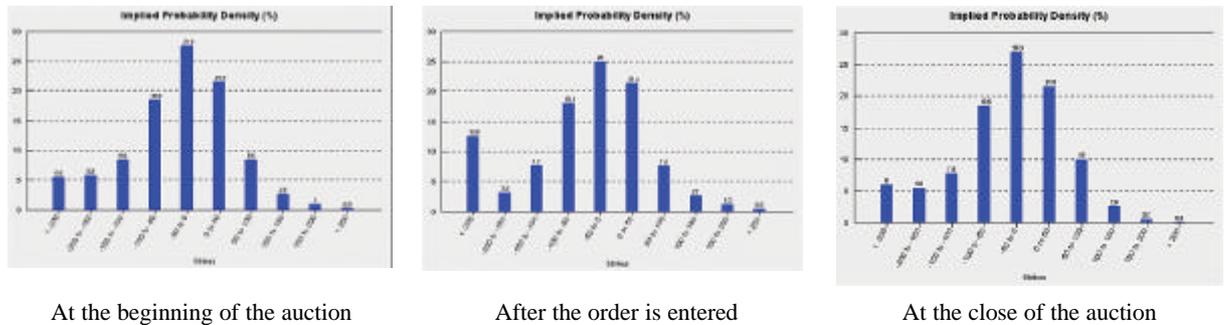


Figure 2.5 Price improvement at a PDCA auction

Source: GS/DB, 2004

Technically, Goldman Sachs and Deutsche Bank act as counterparties on the option contracts. However, their exposure may be virtually zero. In a parimutuel auction, all derivatives that settle in-the-money are funded by those that settle out-of-the-money, so that the system is risk neutral, or self-hedging. The sponsoring banks derive their profit from charging an execution fee, as well as from proprietary trading.

Having the above benefits, the PDCA technology indeed represents an interesting innovation and merits a more detailed description of its mechanics.²⁵ A PDCA option is conducted by a ‘sponsor’ (a financial intermediary). The sponsor selects an underlying variable U , and holds the auction sometime before the value of U becomes known. Depending on the range of the likely outcomes of U , the sponsor also determines the strike prices k_1, k_2, \dots, k_{S-1} , where $k_1 < k_2 < \dots < k_{S-1}$, for the derivatives to be traded on the underlying. The $S - 1$ strikes divide the outcomes of U into S states, and each state is assigned a ‘fundamental’ state-contingent claim (an Arrow-Debreu security). For example, the state $S = 1$, associated with the outcome $U < k_1$, has a digital put option with a strike k_1 as a state-contingent claim. The second state-contingent claim is a digital range with strikes of k_1 and k_2 , which pays out a fixed amount if $k_1 = U < k_2$. The state S (outcome $U = k_{S-1}$) is associated with a digital call struck at k_{S-1} . Then, at the start of the auction, the sponsor is required to enter (small) opening orders $?_s$ for

²⁵ The mathematics of the PDCA technology is described in Baron and Lange (2003) and in Baron (2004).

all state-contingent claims, thus taking only very limited exposure to the underlying. During the auction the participants submit orders $j = 1, 2, \dots, J$, requesting a specific number of contracts n_j and the limit price w_j that they are willing to pay or receive.

To determine the PDCA equilibrium, all derivatives ordered are first replicated with state-contingent claims by determining notional amounts $a_{j,s}$ of each state-contingent claim s for every order j , i.e. replication weights of state-contingent claims, which must be non-negative. For example, in case of a buy order for a digital call with strike k_v that pays a fixed amount if at expiry $U = k_v$, the replication weights are determined as follows:

$$a_{j,s} = \begin{cases} 0 & s = 1, 2, \dots, v \\ 1 & s = v + 1, v + 2, \dots, S \end{cases} \quad (2.5)$$

This set of state-contingent claims will have the same payout as the digital call. If there is an buy order for a vanilla call spread with strikes k_v and k_w , it can be replicated with the following weights:

$$a_{j,s} = \begin{cases} 0 & s = 1, 2, \dots, v \\ E[U | k_{s-1} \leq U < k_s] - k_v & s = v + 1, v + 2, \dots, w \\ k_w - k_v & s = w + 1, w + 2, \dots, S \end{cases} \quad (2.6)$$

In this case the replication weights are based on conditional expected value of the underlying.

The equilibrium price p_s of the state-contingent claim s in PDCA auctions is assumed to be non-negative. Prices of all state-contingent claims add up to unity, and may be also interpreted as implied probabilities of respective states. The equilibrium price p_j of a derivative requested in order j is then determined as:²⁶

$$\mathbf{p}_j \equiv \sum_{s=1}^S a_{j,s} p_s, \text{ where } p_s > 0 \text{ and } \sum_{s=1}^S p_s = 1. \quad (2.7)$$

Since the equilibrium price p_j of the derivative may not necessarily equal the limit price w_j of the order j , the number of filled contracts x_j for the order is calculated according the following logic (for a buy order):

²⁶ It is assumed here that the sponsor does not charge fees.

$$\begin{aligned}
w_j < \mathbf{p}_j &\rightarrow x_j = 0 \\
w_j = \mathbf{p}_j &\rightarrow 0 \leq x_j \leq n_j \\
w_j > \mathbf{p}_j &\rightarrow x_j = n_j
\end{aligned} \tag{2.8}$$

The total premium M paid in the auction is defined as the sum of the premiums paid by the participants plus the sum of the opening orders:

$$M \equiv \left(\sum_{j=1}^J x_j \mathbf{p}_j \right) + \sum_{s=1}^S \mathbf{q}_s . \tag{2.9}$$

The total payout to participants y_s is defined as:

$$y_s \equiv \sum_{j=1}^J a_{j,s} x_j . \tag{2.10}$$

To make the system self-hedging, the PDCA imposes the following condition, which is the cornerstone of the system:

$$y_s + \frac{\mathbf{q}_s}{p_s} = M \text{ for all } s = 1, 2, \dots, S. \tag{2.11}$$

Thus, the amount needed to settle all the filled requests for every state must be equal to the total amount of premium collected. The relative prices of the contingent claims are also set equal to the relative amount of cleared premium m_s for those contingent claims, i.e. for any two state-contingent claims:

$$\frac{m_1}{m_2} = \frac{p_1}{p_2} . \tag{2.12}$$

Finally, the total premium M is maximized subject to all constraints described above. The resulting solution provides the unique equilibrium, which determines the no-arbitrage prices of derivatives in the auction. PDCA effectively aggregates liquidity across all derivatives without necessarily matching buy orders with sell orders. In fact, PDCA can clear significant volume without any sell orders.

Applications The Economic Derivatives are marketed by the sponsoring banks as a tool to hedge risks associated with data release shocks, as well as a way to take speculative positions.

According to reports by Goldman Sachs, most of the participants have been using the new products as a hedge (Cass, 2003).

Market players exposed to risk associated with economic data releases clearly benefit from Economic Derivatives. Before the introduction of the new instrument they had been already hedging against adverse data release shocks through other financial products, which usually did not provide a perfect hedge. Economic Derivatives offered these market players a much more precise instrument. For example, a trader running a short equity book or a strategy based on monetary easing can hedge against a sharp increase in non-farm employment, which may cause the Treasury securities to fall in price, by buying a call option on the non-farm payrolls auction.²⁷ If the actual number turns out to be higher than the strike of the option, its payout will cover, at least partially, the loss on the bond portfolio. Another example is the HIPC derivatives, which are used to hedge exposure to inflation-linked swaps and government securities. The recently introduced GDP auctions may also appeal to the corporations looking for a hedge against the risks associated with the economy.

Some economists and market participants, however, labeled the project as entirely speculative and similar to a casino game. According to one economist, the Economic Derivatives market “seems to be like betting black or red on the roulette table” (Chow, 2002). This point of view may have its merits, especially for certain statistics that are very volatile, such as weekly unemployment claims. Some practitioners also claimed that Economic Derivatives would make poor hedges unless they can be tightly linked to a position, as in the case of interest rate swaps (Thind, 2002).

Nevertheless, as contracts on information events, Economic Derivatives have proved useful. It is observed that the releases of scheduled macroeconomic announcements have an immediate influence on financial markets. For example, the highest price volatility in the US Treasury market is typically found in intervals of just a few minutes around these announcements, reflecting a market reaction to a surprise (Gadanecz, 2003). In the past, speculators could take

²⁷ A positive surprise in a macroeconomic indicator would, in theory, increase the market’s expectation of future monetary tightening and lead to an immediate fall in Treasury prices. This negative correlation between announcement surprises and price movements was found to be especially strong for non-farm payrolls, but Furfine (2001) discovered cases when the direction of the price change in response to employment surprises was inconsistent.

a position only on the direction of the surprise, i.e. whether the actual number exceeds or falls short of the expectations, by taking positions in Treasury securities. Economic Derivatives provided speculators with a tool for taking positions precisely on the quantitative outcome of the event.

An obstacle to a wider application of Economic Derivatives as a hedging tool lies in the design of most auctions, which makes the instruments traded very short-dated, as can be inferred from Table 2.2. At the exception of HIPC auctions, Economic Derivatives are traded just before the release, so the contracts themselves have maturity of only half an hour or so. Such very short-term instruments can be still used to hedge the shocks from the data releases, but following longer-term trends would require participating consistently from auction to auction. Technically, however, there are no barriers to extending the maturity of Economic Derivatives, so that they can be used more widely in hedging.

Economic derivatives have fulfilled well the third function of macroeconomic derivatives – that of revealing the market expectation of the outcomes of a particular economic variable. The market in general watches closely the results of the auctions, and the forecasts of the most important data releases implied by the auctions are reported by financial news services. As Figure 2.6 demonstrates, over the past two years the forecasts implied by the auctions have been fairly consistent with the consensus forecast of the Wall Street economists surveyed by Reuters, with a correlation coefficient between these two numbers of 0.967 (see Appendix for data and correlations for various auctions).

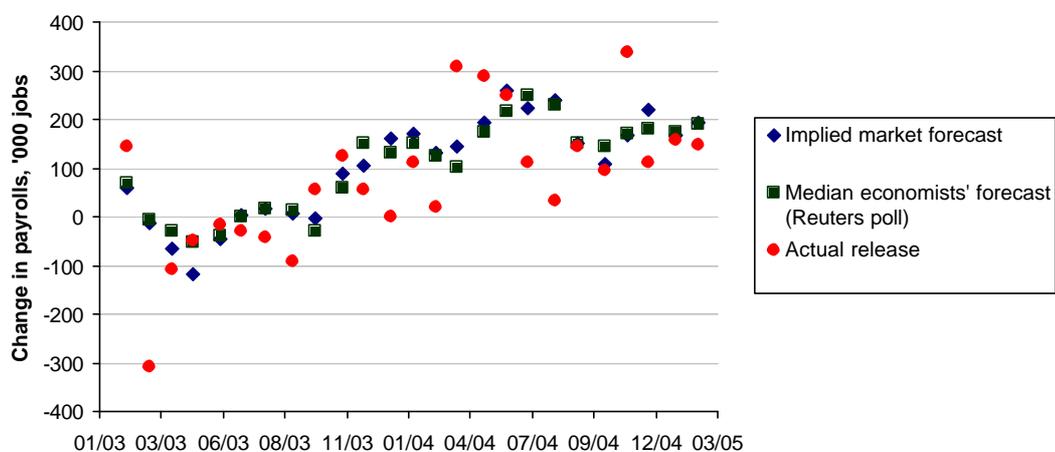


Figure 2.6 Implied market forecasts at US non-farm payrolls auctions

Source: Reuters News, <http://www.icapecoenderivatives.com>, Yahoo Briefing Economic Calendar (<http://biz.yahoo.com/c/e.html>)

It is important to note that the implied market forecasts are based on the probabilities of the various outcomes of a macroeconomic data release calculated during the auction. Since these probabilities are attached by the market under the no-arbitrage condition imposed by the design of the PDCA system, they are risk-neutral probabilities, which incorporate risk premia. Hence, an outcome to which the auction participants are averse will be assigned a higher implied probability, relative to the objective probability. The distribution of economists' forecasts, on the other hand, are based on empirical probabilities, so the market forecast implied by an Economic Derivatives auction and the economists' consensus should, in theory, somewhat differ (Gadanecz, 2003).

2.3.2 Other developments

Although being of smaller scale and potential than previous example, a number of other developments in the field of macroeconomic derivatives are worth mentioning as well. This subsection reviews the cases of CPI futures traded at the Chicago Mercantile Exchange (CME), house price warrants issued by Goldman Sachs in the UK, and retail online exchanges.

CPI futures at CME In February 2004 the Chicago Mercantile Exchange, despite previous unsuccessful attempts (described in subsection 2.2.1), launched a new CPI futures market. CME reasoned that derivatives on economic statistics would be a useful tool for investors, since economic indicators do move markets. Among different economic variables, Consumer Price Index was deemed to be most likely to succeed as a reference index for a futures contract. Many investors at the time were concerned about a possible rise in inflation in the immediate future (Srinivasan, 2004).²⁸ In a survey of inflation-indexed Treasury securities and the broader inflation-protected fixed-income securities markets, conducted in autumn 2003 by the Bond Market Association, 71.7 percent of the respondents indicated that they would utilize a futures contract based on the U.S. CPI. Moreover, about two-thirds of the respondents supported the idea that the introduction of an inflation futures market would increase corporate issuance of inflation-linked debt.²⁹

²⁸ In fact, in 2004 the CPI did experience the biggest increase in four years – by 3.3 percent (Guo and Kliesen, 2005).

²⁹ “TIPS Survey”, Bond Market Association, December 2003, available at <http://www.bondmarkets.com>.

Having registered an interest in inflation futures from market participants, CME reviewed the failed attempts to create such markets at CSCE and CBOT, but decided that the obstacles, which hampered these previous efforts, subsided. First, inflation-linked securities in general gained acceptance amongst investors. TIPS had been rapidly growing since their introduction in 1997, and evolved into an asset class broadly distributed across a large number of investors. Second, there was an expanding over-the-counter dollar-denominated inflation-indexed derivative market, which stimulated demand for a standardized exchange-traded product that could benefit the dealers in these customized risk-management tools. Finally, the pricing of the new futures was better understood by the market participants: a liquid market in TIPS permitted arbitrage between the inflation-linked Treasury securities, nominal Treasury securities and CPI derivatives.

CME's strategy was to mimic the relationship existing between Eurodollar futures and Interest Rate Swaps. The exchange launched a series of 3-month inflation futures, which would serve as hedging instruments for TIPS and as building blocks for inflation swaps. By being multi-purpose CPI futures do not enter in a direct competition with TIPS (which was another obstacle to previous attempts), but rather complement them. CPI futures were designed to expand the market by attracting new players and by allowing new applications, such as term REPOs in TIPS (on real rates) and synthetic inflation-indexed corporate bonds.

By their nature CME CPI futures are quite simple and resemble the 3-month Eurodollar futures. However, CME CPI Futures are backward-looking contracts (unlike Eurodollar futures). The CPI futures contract represents the inflation accretion on a notional value of \$1,000,000 for a period of three calendar months, implied by the Consumer Price Index – U.S. city average for all urban consumers, all items, not seasonally adjusted (CPI-U), as published by the Bureau of Labor Statistics.³⁰ For example, the Reference CPI Futures Index for the June 2004 contract is computed using the annualized percentage change from the CPI-U for February 2004 (released in March 2004) to CPI-U for May 2004 (released in June 2004). If the CPI-U for February and May 2004 are 184.4 and 185.4 respectively, the reference index for the June 2004 contract will be:³¹

³⁰ I.e. the same index as utilized in TIPS.

³¹ Example taken from Srinivasan (2004).

$$100 - \left\{ 4 \times 100 \times \frac{185.4 - 184.4}{184.4} \right\} = 97.83$$

The CPI futures are cash settled and traded through CME's GLOBEX electronic trading platform. The market has a designated lead market maker, who provides liquidity and automated two-sided price quotes. Initially, 12 consecutive March quarterly contracts were launched, with settlement months from March 04 through to December 06, so that the CPI futures could bridge the gap to TIPS maturing in January 2007. Strips of contracts can also be traded.

The Exchange envisions that the CPI futures can be used in the following ways:³²

- Investors TIPS can acquire long positions in CPI futures in order to isolate nominal interest rates in these products.
- TIPS holders can use CPI Futures to hedge short-term inflation risk, including the inflation risk in the accretion of TIPS principal, which arises due to the three-month delay in the accretion.
- CPI futures can be combined with Treasury futures contracts traded at CBOT to create "synthetic TIPS", e.g. for arbitrage purposes.
- Portfolio managers and pension funds with substantial positions in regular nominal corporate debt issues or conventional U.S. Treasury notes can create synthetic inflation-indexed securities by combining a short position in the CPI futures with a portion of their long cash positions, thereby isolating the real rates. Similarly, CPI futures can be used with inflation-linked securities to isolate nominal interest rates.
- Arbitrageurs can trade strips of consecutive quarterly CPI Futures expirations against strips of 3-month Eurodollar futures (a CPI Eurodollar spread) in order to express position on forward real rates.

³² According to the CME CPI Futures brochure, 8/12/2003, available at <http://www.cme.com/cpi>.

- With a strip of consecutive contract months, users can also hedge longer-term inflation risk. In particular, OTC swap dealers can price inflation swaps based on strips of CPI futures and hedge their risks with it.
- Traders in the OTC U.S. dollar inflation-indexed swap market can buy CPI futures as a hedge if they are “receiving inflation” in a swap or, conversely, sell CPI futures if they are “paying inflation” in a swap.
- In addition to using the CPI strip for long term swaps, holders of short TIPS can hedge out the exposure to a particular CPI release.

The prices of CPI futures capture market expectations of future inflation and the associated risk premium. Assuming that the latter is negligible, another potential use of the CPI futures contracts is to gauge the future inflation rate relative to the current rate. However, the inflation outlook implied by CPI futures prices should be viewed cautiously because CPI futures contracts are still relatively illiquid and have sizable bid-ask spreads (Guo and Kliesen, 2005).

New Argentine Bonds Argentina, facing a major economic and financial crisis, defaulted on most of its public debt in December 2001. Facing the need to restructure its liabilities in order to make the external debt more sustainable and reduce the vulnerability to shocks in future, the Argentinian government, possibly on advice from the IMF, decided to offer its bondholders to exchange the distressed debt for new bonds linked to the country’s economic growth. The financial community, in principle, received the plan well: investors welcomed the opportunity to have additional payments during the times of good performance and the eventual reduction of the default risk. Some potential issues were pointed out as well, in particular the credibility of the data and the proper valuation of the bonds. In addition, some expressed concerns over the possibility of moral hazard, i.e. that the country could become unambitious about its growth if the threshold (the strike) of the warrant had been set too low (Pruitt, 2003). The US\$81.8 billion exchange offer to the bondholders was, nevertheless, made in autumn 2004. Argentina offered three different types of bonds, clearly targeted to different groups of bondholders: Par bonds due 2038, Discount bonds due 2033 (with a 30.1% nominal discount), and Quasi-par bonds (with a 66.3% nominal discount) due 2045. All bonds are issued in a package with a GDP-linked warrant, but the latter *detaches automatically* after 180 days from the date of exchange (April 1st, 2005) and will trade independently. The warrants have a maturity of 30 years and an annual payment of 5% of ‘excess GDP’, defined

as the difference of the real GDP of the reference year published by the Argentinian National Statistics Institute (INDEC) and the ‘base case’ GDP defined in the exchange offer (see Fig. 2.7). The conditions for the payment are the following: (1) the actual real GDP exceeds the base case GDP, (2) the actual real GDP growth exceeds the base case GDP growth, and (3) the payment cap of the GDP-linked security, equal to 0.48 per unit of currency during the life of the warrant, is not exceeded. It is worth noting that the warrant payments have a one-year lag, i.e. the payment for the 2005 reference year will be executed, if conditions are met, only on December 31, 2006.

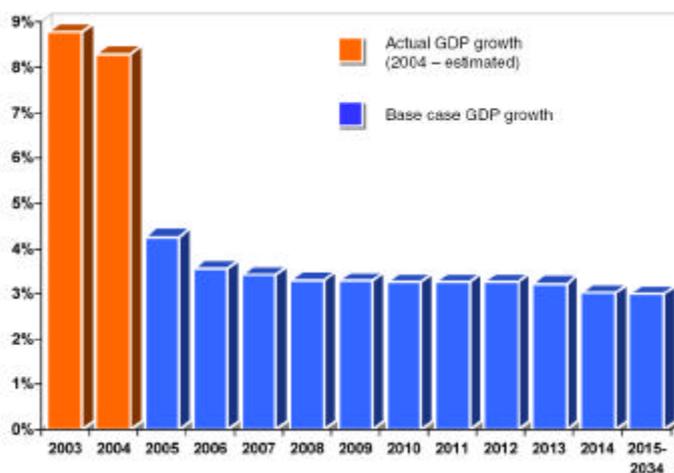


Figure 2.7 Base case GDP growth for Argentina’s warrants

Source: *Oferta de Canje (Exchange offer presentation)*, República Argentina, 12/01/2005, available at http://www.argentinedebtinfor.gov.ar/ing_presen.htm.

According to press reports, many bondholders, especially retail creditor groups, regarded the terms of the exchange as less than adequate. Possible reasons for the investors’ concerns seemed to be related not to the structure of the new bonds, but rather the conditions of the offer, such as low interest rates, long maturities, as well as disregard of the unpaid interest for the period 2002-2003. In total, analysts estimated that the overall loss to investors might be as high as 70%³³. It is also conceivable, nevertheless, that certain design features of the new bonds, including the complexity of the payoffs and an interest payment cap, could have

³³ As reported by Reuters (Milliken, 2005). It is worth noting, however, that during 2003-2004 Argentine defaulted debt traded on the market at around 30 cents on the dollar, suggesting that the offer was, in fact, made at the equilibrium value of the Argentine debt (Roubini, N. “The Successful End of the Argentine Debt Restructuring Saga...”, <http://www.roubiniglobal.com>, 02/03/2005)

contributed to the discontent of the bondholders. Despite the concerns, however, the exchange offer was accepted by 76% of the holders of Argentine debt (Milliken, 2005). It remains to be seen how the warrant issued under the terms of this exchange offer performs, but this case certainly marks an important milestone in the history of macroeconomic derivatives, even if only due to the size of the issue.

House Price Warrants In May 2003 Goldman Sachs started offering warrants and certificates³⁴ on both UK home prices and Greater London home prices, with an expiration date in 2004. These securities were cash settled based on the Halifax House Price Indices. The warrants were rather attractive to investors, since they were deep-in-the-money and had relatively limited downside risk (Smith, 2003). In August 2004 Goldman Sachs issued a new range of warrants and certificates linked to one specific future level of the Halifax All Houses, All Buyers, Standardized Average House Price index (seasonally adjusted) in the UK for June 2006. The new issue is currently traded on LSE. The warrants provide investors with a flexible means of gaining exposure to UK residential property prices. Similar to CFDs, warrants and certificates offer some advantages over purchasing the physical asset directly: short and long exposure (both puts and calls are available), exemption from Stamp Duty, low transaction costs, diversification, and low absolute size of a single security.

Online Platforms The development and spread of information technology opened new opportunities for developing retail financial markets, including those for derivatives. One such Internet-based exchange, HedgeStreet, has been opened in October 2004. HedgeStreet offers contracts of a proprietary type, dubbed ‘Hedgelets’, which allow investors to take positions on a future outcome of a particular economic variable. An individual contract represents a position, either ‘Yes’ or ‘No’, on whether a specific outcome will or will not happen. The contracts are in effect binary call and put options and ranges that pay a fixed amount (\$10) if the option expires in-the-money and zero otherwise. For example, a ‘Gasoline > \$2.125 Yes’ contract would pay \$10 if the price of gasoline is greater than \$2.125 on the

³⁴ Warrants and certificates are derivative securities that are listed and traded on the London Stock Exchange. A warrant is much like an option, for which an investor pays a fraction of the price of the underlying asset (as a premium). Certificates are similar to warrants, except that they are unleveraged and, as such, track the underlying asset directly (i.e. they are call warrants with a strike price of zero). Investors can only buy warrants and certificates, and hence can never lose more than their initial investment.

expiration date. The contracts can also be bought or sold among trading members at market prices before expiration. Obviously, the price of a single contract cannot be higher than \$10, which makes the market accessible to retail investors. The exchange does not allow margin trading, so the gains and losses of the participants are limited.

Hedgelets are issued and redeemed in pairs (digital call and put), representing all possible mutually exclusive movements in the underlying index for the pair. The pair, hence, bears no risk and has a value of \$10. After the pair is issued, the contracts constituting the pair can be traded separately. Any two contract that form a pair can be automatically redeemed by the exchange.³⁵ Like a regular exchange, HedgeStreet only facilitates trades and does not take positions on its own account, remaining completely risk-neutral. Participants always trade among themselves in a zero sum market. The exchange also recruits market makers among its members, so that they maintain a two-sided quote at a predefined spread for specified instruments.

Currently, HedgeStreet offers contracts on indices in five sectors:

- Finance (currencies, commodities, and interest rates);
- Economics (inflation and economic activity);
- Real estate (mortgage rates and residential property);
- Goods and services (energy);
- Income (employment).

The residential property contracts include several options on quarterly changes in U.S. regional house prices, settled according to House Price Indices published by the Office of Federal Housing Enterprise Oversight (US Department of Housing and Urban Development). The economic and employment data contracts include options on CPI-U, Retail Sales (excl. autos), Non-Farm Payrolls, and Initial Unemployment Claims.

³⁵ The automatic creation and redemption of the pairs resembles that of Shiller-Weiss 'macro securities' (cf. Shiller 2003, pp. 126-129)

HedgeStreet positions its products primarily as hedges. Indeed, options such as those on residential property might be appealing in this quality to retail investors, as they could protect homeowners from equity losses in the case of falling house price. However, HedgeStreet's instruments are too short-term: a contract on house prices should have maturity of at least several years to be effective as a hedge. With short-term contracts the new market is likely to be dominated by speculators, if it manages to gain sufficient liquidity at all. Some critics also contend that average investors are not sophisticated enough to forecast the direction of the indicators on which they take positions (Nasaw and McDonald, 2004).

Contracts on economic data are also available at an online betting exchange operated by Trade Exchange Network, Ireland. The exchange's websites, TradeSports and Intrade, currently offer binary call options on various economic numbers, including US consumer confidence figures, ISM Manufacturing, Producers Price Index, CPI, Durable Goods Orders, Initial Unemployment Claims, GDP, and Existing Home Sales. Contracts have a fixed payout of \$10 and typical maturities of 7-10 days.³⁶ TradeSports/Intrade operates as an exchange that facilitates trading by matching orders from its members and fulfils a clearing function, but does not enter into the trades. TradeSports/Intrade enters agreements with independent market makers to post the initial offers. For the moment, however, trading volumes of macroeconomic contracts remain low relative to other financial index contracts traded on the exchange.

Clearly, TradeSports/Intrade's contracts are intended mostly for speculators, since it is primarily a betting exchange. However, the conditions offered to the investor and instruments themselves are not very different from those of HedgeStreet, and they potentially can be used for hedging as well. In any case, both examples demonstrate that trading macroeconomic derivatives, for all purposes, can be made available to retail investors and that the interest in such products might be growing.

³⁶ It is worth noting that although the contracts have longer maturity than most Economic Derivatives, the volume in TradeSports/Intrade's macroeconomic contracts typically starts to build up only closer to the date of settlement.

2.4 Intermediate conclusions

The analysis in this chapter shows that macroeconomic derivatives have unique features and the potential to be beneficially employed in a number of practical applications. Theoretical considerations do support their usefulness, and their history demonstrates an interest in such instruments among market participants. It is also acknowledged that the introduction of macroeconomic derivatives faces a number of practical challenges. These obstacles, however, do not seem insurmountable. In fact, macroeconomic derivatives have already started to gain acceptance on the market.

As section 2.3 shows, macroeconomic securities are being created in a number of ways. Of these, the OTC auctions and GDP-linked sovereign bond issuance are, probably, the most promising ones. The Economic Derivatives market already has a good track record and the potential to grow in terms of liquidity, the variety and maturity of the instruments offered. The issuance of the GDP-linked debt has the potential to create, in turn, an international market for long-term warrants on GDP. Both developments suggest exploring the numerous practical applications of macroeconomic derivatives in general and GDP derivatives in particular.

3. An application for GDP derivatives

This chapter focuses on the case of (embedded) derivatives, which have economic growth, measured as the rate of change in GDP, as their underlying. Specifically, the following sections provide a discussion of the merits of using GDP derivatives in conjunction with sovereign debt securities, as well as present some quantitative evaluation of this application.

3.1 The case for GDP-linked bonds

This section builds the case in support for GDP-linked bonds by describing the way they work and discussing the benefits they might provide to the issuers, examines major problems associated with the GDP-linked bonds and offers some solutions. Before proceeding to a description of the specific structure of GDP-linked securities, however, it is useful to review the literature related to the case.

3.1.1 Literature review

Indexing sovereign bonds to some macroeconomic variable is not entirely a new idea. A first wave of interest in indexing debt to GDP, exports or key commodity prices in academic circles emerged due to the debt crisis of the 1980s. At the center of the discussion were the relative merits of indexing sovereign bonds to variables beyond the issuer's control (such as commodity prices) versus variables partially under the issuer's control (exports or GDP). At the time, the majority emphasized the problems of indexing debt to macroeconomic variables rather than the insurance benefits that such indexing could provide to the issuers. Moreover, the decline in commodity prices was considered as one of the major causes of the 80's debt crisis, and commodities accounted for a significant share of output and exports for some of the countries most affected by the crisis. In the light of these considerations, indexing sovereign debt to commodity prices appeared to be a better idea (Borensztein and Mauro, 2004).

During the 1990s GDP-indexed bonds received some more theoretical and practical support. Barro (1995) studied dynamical optimal taxation in an equilibrium model that yielded a form of tax smoothing as a basis for debt management. The key recommendation of his paper was that public debt should be indexed to the price level and have long-term maturity.

Additionally, a full program of optimal taxation, according to Barro, would call for indexing debt payments to the tax base (aggregate consumption in his model) and the level of government spending. However, he acknowledged that GDP might be easier to define and measure than aggregate consumption and suggested that GDP-linked bonds – or securities similar to those proposed by Shiller (1993) – would be a more realistic alternative. In practice, the introduction of GDP-indexed bonds was proposed by some investment banks in Sweden in the mid-1990s. The idea received some support from the government, but was never realized, partly because the National Debt Office at the time was focused on promoting greater use of inflation-indexed bonds (Borensztein and Mauro, 2004). For emerging market economies, the case for contingent debt contracts came again into the light after the financial and debt crises of the 1990s. As shown in Chapter 2, GDP-linked bonds were issued at that time by Costa Rica, Bosnia and Herzegovina, and Bulgaria.

The discussion of the merits of indexing sovereign debt to some macroeconomic variables has been revived more recently, and the recent Argentina's exchange of its defaulted debt into new GDP-linked securities has also added a major practical dimension to the discussion. Several researchers recommended that countries issued bonds with contingencies to commodity prices or other external variables of relevance to them. Drèze (2000a and 2000b), basing on the theory of efficient risk-sharing, proposed that countries should issue perpetual bonds with annual dividends proportional to the country's national income and then exchange the bonds among themselves to share the risks. In particular, he suggested restructuring the debt of poor countries in the form of bonds indexed to the country's national income net of a deductible. The deductible in his proposal was designed to exempt individual incomes below a subsistence level from contributing to debt service and to allocate some government revenue for meeting basic human needs before servicing the debt. Drèze, however, argued that GDP-indexed bonds should not be exchange-traded, since market prices of the assets indexed to a country's national income might be interpreted by voters as a measure of a government's performance and the excess volatility of financial markets could introduce noise in policy evaluation.

Borensztein and Mauro of IMF in their two papers (2002 and 2004) put forward a strong case for reviving GDP-linked bonds. Their approach is based mostly on the use of bonds with a floating rate indexed to the annual GDP growth rate. They showed that such GDP-indexed bonds could provide substantial benefits in reducing the likelihood of default crises and allow

countries to avoid procyclical fiscal policies. They also considered the issue of an insurance premium that a borrower might have to pay for the indexation of its debt, the potential obstacles to creating a market for GDP-linked bonds and suggested an approach to attempting to start up such market.

Schröder et al. (2004), in a study commissioned by the German Ministry of Finance, examined the applicability of GDP-linked bonds for the financing of developing countries based on a quantitative analysis of their pricing behavior, price sensitivities to changes in GDP, and their performance in a portfolio context. Their study also considered the possibility of adding public guarantees provided by an international organization such as the World Bank to partially insure the default risk of the GDP-linked bond. Based on simulations, the paper reaches a conclusion that GDP-linked bonds would be, in general, close substitutes to existing sovereign bonds. GDP-linked bonds might be chosen by some investors if GDP of the borrowing country has a negative or low positive correlation with the GDP of the reference region of the investor (or world GDP for well-diversified investors). These results, however, depend on a number of questionable assumptions of the study: the authors do not adjust default probabilities, interpolate “daily GDP” and use the Black-Scholes model for warrant pricing.³⁷

Kletzer (2004), basing on consumption-smoothing models, found theoretical support for the use of derivatives on GDP, commodity prices or other variables in sovereign borrowing. He suggested that such contingent debt contracts could bring substantial gains and might be useful for eliminating costly bond renegotiation, which is a form of imperfect risk sharing. Derivatives associated with sovereign bonds would provide insurance for the debtors and reduction of the default and restructuring risk for the bondholders. Also, according to Kletzer, debt renegotiation demonstrates that sovereign debt contracts are implicitly state-contingent contracts, and this feature provides some sort of international sharing of country-specific risks across borders. In this framework, adding derivatives to sovereign bond contracts would formalize the implicit contingencies and, thus, reduce the frequency of costly renegotiations and, ultimately, raise welfare by increasing risk sharing for public and private borrowers in emerging markets. However, Kletzer argues that derivatives should not be embedded into bond contracts but issued as separate instruments. This would allow investors with different

³⁷ The potential inappropriateness of these methods will be addressed below.

monitoring capacities, risk attitudes and needs to choose between low-risk bonds and risky derivatives. Ultimately, if markets in such securities are created, they could reduce macroeconomic volatility in debtor countries and increase capital flows to developing economies.

3.1.2 How GDP-linked bonds work

GDP-linked bonds in general work as follows. In a hypothetical case, a country, whose real GDP has been growing at an average rate of 3%, might have been issuing sovereign bonds at an average interest rate of 7%. The country could, then, consider issuing GDP-linked bonds whose yearly or quarterly coupon payments will be increased by, for example, one percentage point for every percentage point by which real GDP growth exceeds the 3% trend. In those years when growth turns out to be lower than the threshold, the coupon will be, for example, 6%, and in years when growth turns out to be higher, the coupon will be increased proportionally. Thus, when GDP growth falls, the country will make only debt payments at a minimum 6% level, which is lower than in the absence of indexation. In the opposite situation, when GDP growth is higher than the threshold, the country will have higher coupon payments than without indexation, which is a benefit to investors.

Mathematically, the coupon rate of a GDP-linked bond at a coupon payment date t may be expressed as

$$c_t = r + a \max [g_t - g^*, 0], \quad (3.1)$$

where r is the non-conditional interest rate, a is a constant that defines the elasticity of coupon payments with respect to changes in economic growth, g_t is the actual GDP growth rate at the coupon payment date, and g^* is the 'baseline' growth rate. The baseline growth rate of GDP is specified at the time of issuance, similar to the strike price of an option. In the example above, thus,

$$c_t = 0.06 + \max [g_t - 0.03, 0].$$

Effectively, the issuing country will be selling a series of independent warrants (call options) on GDP to its investors together with a straight bond. The two securities can be, then, sold separately by the issuer, or the warrants can be easily stripped on the market.

Borensztein and Mauro (2004) propose other forms of debt indexation to GDP as well. For instance, a GDP-linked security may be structured as a floating rate bond. The coupon rate of such bond would vary depending on the performance of the domestic economy, according to the following formula:

$$c_t = r + (g_t - g^*), \quad (3.2)$$

which is similar to a portfolio of a straight bond and a swap. It is conceivable, however, that many institutional investors would be prohibited to hold such instruments due to their potentially negative coupons, and thus, the following formula with a zero floor would be more feasible:

$$c_t = \max [r + (g_t - g^*), 0]. \quad (3.3)$$

In this case, the coupons can also be represented as a series of call options with a negative exercise price. However, even this type of indexation may be unacceptable to some investors, who prefer, possibly because of the provisions of the funds they manage, a guaranteed minimum coupon payment.

The indexation could also be non-linear, as in the following formula:

$$c_t = r + \mathbf{a} \sqrt{\max(0; 100g_t)} / 100. \quad (3.4)$$

This type of indexation gives a better correlation of coupon payments with growth rates, while guaranteeing a minimum coupon payment (Borensztein and Mauro, 2004). On the other hand, such bonds might be more difficult to market to the investors due to the complexity of the securities' payoffs and, hence, their pricing.

GDP-linked debt, especially in form (3.2), would ensure that the debt/GDP ratio of the issuing country is maintained at sustainable levels and within a narrower range than in the case of financing by straight bonds. Figure 3.1 demonstrates the effect of GDP floaters and bonds with GDP warrants on the debt/GDP ratio. It is assumed that economic growth develops according to two scenarios: 'rise' and 'decline'. The growth rate process is simulated as follows:

$$g_t = 0.03 \pm 0.002t + \mathbf{e} / 100, \quad \mathbf{e} \sim N(0,1), \quad (3.5)$$

where e is a normally distributed random variable. The resulting growth paths are demonstrated in Fig. A.1 in Appendix. The debt to GDP ratio is calculated according to the following formula:

$$D_t/Y_t = (1 + c_t - g_t)(D_{t-1}/Y_{t-1}) - s_t, \quad (3.6)$$

where D_t is government debt, Y_t is output, s_t is the primary surplus as a share of GDP, g_t is the growth rate, and c_t is the interest rate. Parameter values are: $s_t = -0.5\%$; $r = 7\%$ for plain vanilla bonds and floaters (type (3.2)) and $r = 6\%$ for bonds with warrants (type (3.1)), $a = 1$, $g^* = 3\%$ for both floaters and bonds with warrants.

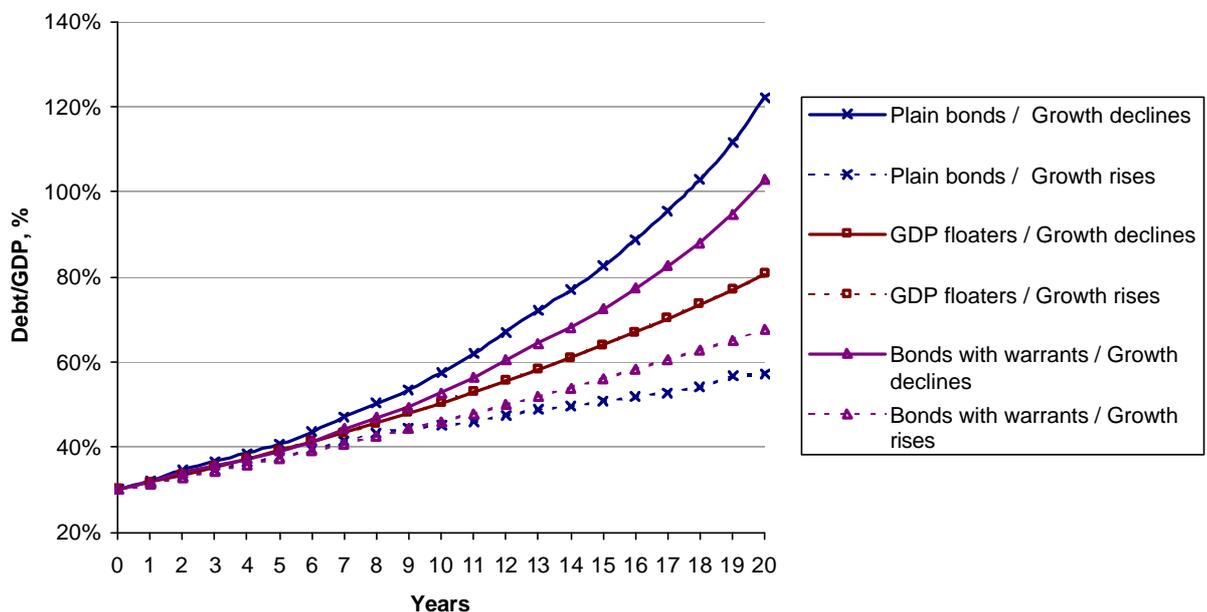


Figure 3.1 The effect of indexing of sovereign to GDP on the debt to GDP ratio

Source: Author's calculations

3.1.3 Benefits to the issuers

By limiting the growth of debt/GDP ratios, GDP-linked bonds could provide two key advantages to the borrowing countries: (1) lower likelihood of defaults and debt crises and (2) lower need to engage in procyclical fiscal policy (Borensztein and Mauro, 2004).

Defaults and debt crises The use of GDP-linked bonds in sovereign borrowing may reduce the likelihood of debt crises and defaults, which typically lead to financial sector distress, capital flight, job losses, and a downward spiral of further declines in output. There is plenty of evidence that the ability of a country to service its sovereign debt depends to a significant

degree on its economic growth. Easterly (2001) found that slow growth played an important role in many debt crises, including the Latin American debt crisis of the 1980s and the debt crisis of the highly indebted poor countries (HIPCs) in the 1980s and 1990s, as well as the increase of the public debt burden of industrial countries in the 1980s and 1990s. In a formal econometric test he also found that GDP growth interacted with initial debt level was a significant variable in explaining the number of external debt reschedulings over 1980-1994, and hence concluded that growth is an important determinant of whether a debt crisis develops. Detragiache and Spilimbergo (2001), using a sample of 69 countries over 1970-1998, showed that countries with a larger ratio of external debt to GDP are more likely to experience a debt crisis.

GDP-linked debt would help to stabilize the debt/GDP ratio, and thus reduce the probability of debt crises. By keeping the debt/GDP ratio at a sustainable level, the indexation according to the floating formula would help to avoid adjustments to the primary balance at a time of weak economic performance, which could be costly and politically difficult. The mechanism is the following: if the economy experiences a period of weak growth, the debt/GDP ratio would increase by a smaller amount with indexed debt than with conventional (plain vanilla) bonds. Figure 3.2 illustrates the effect of GDP-linked debt on the debt servicing payments on the case of Mexico and Argentina over the period of 1991-2002. It is supposed that since 1990 half of the total government debt of each country consisted of GDP floaters, with $r = 7\%$ and baseline growth g^* calculated as the average growth rate over the previous 20 years. It is further assumed that the composition of debt does not influence any other economic variables. For Mexico, the average growth over the 20 years to 1990 amounted to 4.4%, while during 1991-2002 growth averaged about 3%. As Fig. 3.2 shows, the use of GDP-linked bonds would have resulted in significant savings on interest payments, especially during the Tequila crisis of 1995 and during a slowdown in 2001-2002. The average coupon rate over 1991-2002 would have amounted to 5.9%, lower than the expected rate of 7%. In Argentina, the average growth during the 20 years to 1990 was 0.9%, while in the following 12 years GDP grew at an average rate of 2.3%. With this particular set of parameters Argentina would have obtained no net savings from the use of GDP-linked bonds, as the average coupon rate would have been 8.8%. The country would have enjoyed interest bill savings in 1995 and during the four

years since 1999, while its investors would have obtained additional payments in the other years³⁸ (Borensztein and Mauro, 2004).

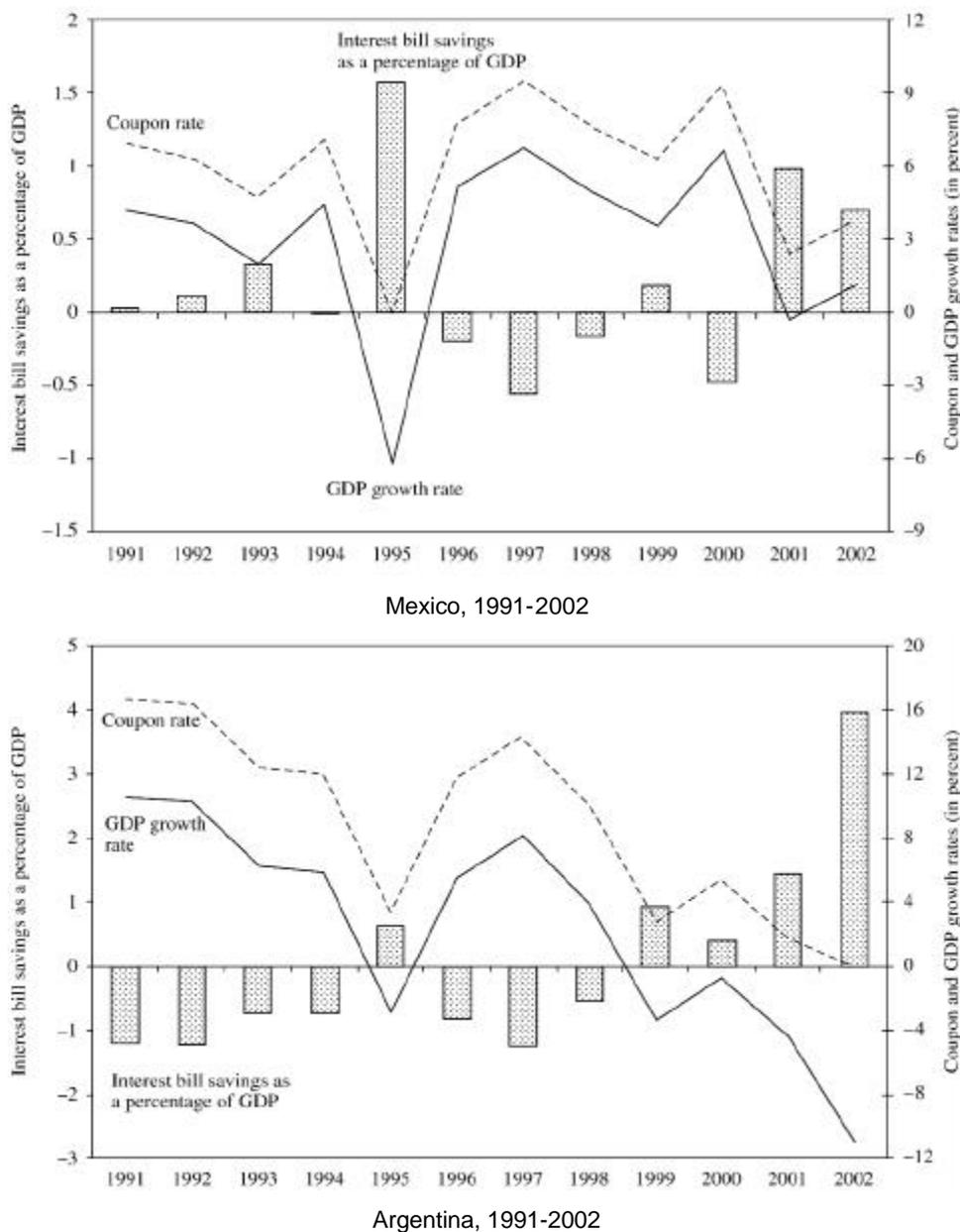


Figure 3.2 Savings on interest payments over the economic cycle

Source: Borensztein and Mauro (2004)

Procyclical fiscal policy During economically weak periods a government may face difficulties in borrowing from private sources, which may force it to engage in a procyclical

³⁸ Towards the end of period the interest bill savings would have resulted also from a significant increase in the debt to GDP ratio due to the depreciation of the peso.

fiscal policy. Similarly, a government may be under pressure to employ such policy when it attempts to stabilize the debt/GDP ratio due to some legal or constitutional constraints, international agreements, or inability to borrow beyond a certain level. GDP-linked bonds can reduce the need for procyclical policies, by acting as an automatic stabilizer. When the economic growth is below trend, the government will be able to have a lower primary surplus (i.e. higher primary spending and lower taxes) with GDP-linked debt than with conventional debt. Conversely, when economic growth is stronger than the baseline growth, the government will need to have a higher primary surplus (i.e. lower primary spending and higher taxes) to accommodate higher interest payment on public debt. GDP-linked bonds would thus smoothen the changes of the primary surplus, taxes, and primary spending over the cycle.

Borensztein and Mauro (2004) estimated the benefits of GDP-linked debt in terms of government's ability to conduct countercyclical fiscal policy through the correlation of the primary balance and the real GDP growth rate. They calculated this measure for 20 advanced countries and 25 developing countries over the period of 1992-2001, assuming that in 1991 the entire debt of each country was indexed to GDP. The indexation was computed using the floating rate formula, where r was assumed to be equal to the implied interest rate from the actual data and the baseline growth taken as average of growth rates during 1980-2001. The results demonstrated that the correlation between the primary balance and real GDP growth would have been considerably higher for both groups of countries if they had used GDP-indexed debt (0.64 vs. 0.40 for advanced countries and 0.77 vs. 0.30 for developing countries).

This comparison shows that GDP-linked bonds could be especially beneficial for developing countries. In fact, these countries often suffer from declines in investor sentiment during periods of slower growth. Their governments are often constrained to adhere to a tight fiscal policy during economic downturns in order to maintain credibility and access to international financial markets, thereby possibly exacerbating the downturn. The phenomenon of procyclical fiscal policy in developing countries, which is not limited only to crisis periods, was documented by a number of studies. Gavin and Perotti (1997), for example, found that fiscal policy in Latin America during 1968-1995 was very procyclical during significant underperformance of the economy, especially in respect to public spending. Talvi and Végh (2000) argued that procyclical fiscal policy seems to be the norm in the developing world, not

just in Latin America. Akitoby et al. (2004) found econometric support for the procyclicality of government spending in developing countries, although with varying degree across spending categories. A recent systematic study by Kaminsky et al. (2004) also confirmed, basing on a sample of 104 countries, that fiscal policy is procyclical in the majority of developing countries, especially in the middle-high income group.

GDP-linked bonds, however, could be also beneficial for certain advanced countries, which face constraints on the deficit level. Such constraints can arise because of legal provisions (e.g. in some of the states in the US), or from international agreements such as the Stability and Growth Pact (SGP) of the EU. The SGP places an upper limit on the annual fiscal deficit equal to 3% of GDP, and some researchers argue that it can force the fiscal policies of the participating countries to become procyclical (Borensztein and Mauro, 2004). GDP-linked bonds can thus be useful to reduce the need to engage in procyclical policy in the EMU countries. Some previous papers also provide other justifications for the use of indexed debt. Obstfeld and Peri (1998), in the framework of their discussion of the need for fiscal transfers within the EU and the dangers of such transfers, suggested that the EU governments issued perpetual euro-denominated liabilities indexed to domestic nominal per-capita GDP growth. They argued that such debt is more efficient than a fiscal transfer system. In this way, the EMU countries would be able to shed some of their macroeconomic risks. Their governments would have net cash flows that would increase in case the growth of GDP is unexpectedly low, much like in a fiscal transfer system, but without a central bureaucratic apparatus to carry out this function. Moreover, each country, they argued, would strive for better performance in order to obtain better terms when marketing their GDP-linked securities. Drèze (2000a) proposed the use of GDP-linked bonds to share macroeconomic risks among the EMU countries on the grounds that such an arrangement is more realistic, as moral hazard and other practical concerns are less of a problem for the EMU countries. In fact, many of the potential obstacles to the introduction of GDP-linked bonds appear to be less significant in the case of the advanced countries.³⁹ The EMU countries, for example, have established and monitored common statistical standards. In addition, financial markets in some advanced countries may be more favorable to GDP-linked bonds. In Italy, for instance, public pension system is indexed to the GDP growth, and private pension funds gauge their performance against the

³⁹ These problems are addressed in more detail in the next subsection.

public pension system. Conceivably, these pension funds might be interested in an instrument whose return is linked to economic growth. In Sweden, as mentioned earlier, the market participants themselves proposed issuing GDP-linked bonds to the government.

The benefits of issuing GDP-linked bonds for the EMU countries were estimated quantitatively by Borensztein and Mauro (2004) as follows. They supposed that two countries, France and Spain, were subject to the 3% deficit limit since 1980. In this case the limit would have been reached by France in 1986 and 1992-1997 and by Spain in 1981-88 and in 1990-97. During these periods the two countries would have been constrained to adjust their primary balance to meet the ceiling, which would have limited their ability to conduct countercyclical fiscal policy (see Fig. 2.3 for France). The correlation between the primary balance and real GDP growth during 1980-2002 for France would have been 0.30 with SGP (0.55 without) and for Spain 0.25 with SGP (0.50 without). If their debt had been linked to debt, the indexation would have offset any impact from the SGP limit: the correlations between the primary balance and real GDP growth would have been much closer for the two scenarios (France: 0.73 with SGP, 0.76 without; Spain: 0.56 with SGP, 0.68 without).

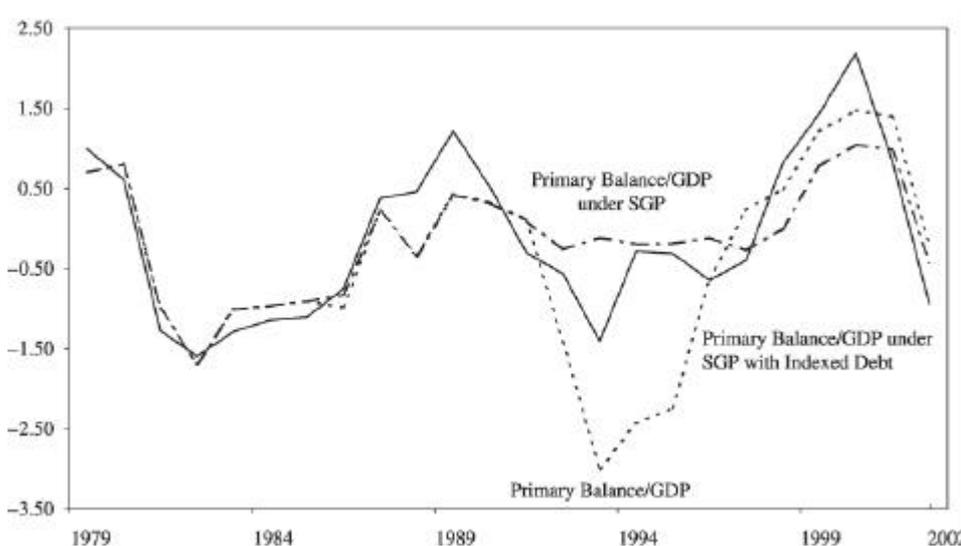


Figure 3.3 France: Primary balance with and without debt indexation to GDP, 1979–2002

Source: Borensztein and Mauro (2004)

Cost of borrowing Borensztein and Mauro (2004) suggest that GDP floaters would provide the issuer with an insurance scheme, for which it would have to pay a premium above the interest rate that it would ordinarily be charged. Basing on a CAPM-like argument, they also show that this premium could be relatively small. However, another approach reveals that the

cost of GDP-linked debt may turn out to the advantage of the borrowing country, rather than to its disadvantage. As shown in 3.1.2, GDP floaters may be represented as a combination of a straight bond and a swap (types (3.2) and (3.3)). Let us consider the straight bond first. Bond yields consist of two components; (1) the yield on a similar risk-free issue and (2) a premium (spread) above the yield on the risk-free issue in compensation for the risk associated with the bond. Since GDP-linked debt would reduce the probability of default, it should also have a lower credit spread and lower yields relative to conventional bonds. The other variant of the GDP-linked bond, a combination of a straight bond and a GDP warrant (type (3.1)), would also command lower yield on its straight component.⁴⁰ Moreover, it can be shown that in order to provide the benefit of reducing default probability the fixed rate of such bond must be lower than for conventional bonds or even GDP floaters. Otherwise, if growth declines, the bond with a GDP-warrant would have the same effect on debt-to-GDP ratio as a conventional bond. The demonstration of the effects on debt/GDP ratio on Figure 3.1, in fact, uses a lower fixed rate for bonds with GDP warrants.

As for the second component, a GDP-floater would have a swap (possibly with a cap on floating payments) or, equivalently, a combination of a call and a put option. The swap, if its fixed rate were determined correctly, would have zero value at the time of issue and, thus, would not require any upfront payment. A bond with a GDP warrant, on the other hand, would bring the issuer an upfront premium on top of the sale price of the straight component. Certainly, future payoffs would depend on the borrowing country's growth rates and on specific parameters of GDP-linked bonds. However, if the issuer's economy underperforms, GDP-linked debt will not be more costly than plain vanilla debt.

There are some additional benefits to GDP-linked bonds as well. For example, they may help governments to maintain a smooth path of tax rates and essential public services despite fluctuations in economic growth, in line with the suggestion by Barro (1995). Borensztein and Mauro (2004) also speculate that higher interest payments in years of higher GDP growth would make it more difficult for governments to boost thoughtless spending.

⁴⁰ This argument ignores other factors that may drive up the spreads but are not directly related to the indexation feature itself. These factors are identified in subsection 3.2.2.

3.1.4 Problems and solutions

Obviously, GDP-linked securities are not immune to the problems and obstacles that hamper the introduction of macroeconomic derivatives (refer to 2.2.2), and may also have some unique ones. This subsection discusses several of these issues that may influence the effectiveness of the GDP-linked instruments or their feasibility, and suggests some counterarguments and solutions.

- **GDP misreporting** It is usually believed that governments have substantial control over macroeconomic statistics. In many countries statistical agencies are independent, but for certain countries such independence may be not absolute. If a large share of a country's external debt is issued in the form of GDP-linked bonds, its government will have a strong incentive to influence the statistical agency so that the latter understates GDP and its growth rate. Due to the possibility of such misreporting, investors may understandably become reluctant to hold GDP-linked bonds. In fact, it may even reinforce the pervasive 'home bias'⁴¹: international investors may not feel sufficiently well informed about the true developments in a foreign economy, compared to the residents of the borrowing country.

On the other hand, there are forces that can counterbalance the incentive to understate GDP. First of all, economic growth is popular with investors and general public, so governments may have even stronger incentive to inflate the reported GDP growth rates for political reasons, rather than to understate them. Secondly, a country may place its reputation, and consequently its access to financial markets, at stake if it misreports the GDP growth rates significantly for a long period of time. For GDP-linked bonds with long maturities, then, GDP misreporting will be less of a problem. Thirdly, some part of a GDP-linked issue is likely to be purchased by domestic investors, who could then lobby to ensure the accuracy of the underlying macroeconomic data. Finally, if occasional episodes of misreporting occur, they would certainly disturb the market, but would not necessarily prevent it from functioning further, as already pointed out in 2.1.1. Stock markets, for

⁴¹ There is evidence that investors' portfolios are underdiversified internationally. For example, Golub (1991) finds that the ratio of foreign assets to domestic assets (equity and bonds alike) was rather low for OECD countries in 1970-1986. Tesar and Werner (1995) arrive to the same conclusion on the data on international investment positions of major OECD countries for 1975-1990 (for both stocks and bonds). This phenomenon may reflect a widespread 'home bias'.

example, have survived many episodes of misreporting scandals. As long as investors have information about potential misreporting, it should be reflected in asset prices and should not create a problem for the market. Overall, in fact, private sector sovereign risk specialists appear to have a reasonably confident view of the reliability of economic data (cf Fridson, 1995).

In any case, there are several remedies to the problem of potential GDP misreporting. Firstly, monitoring on the part of international agencies should help ensure the accuracy of countries' GDP data. The efforts of the IMF to encourage its members to subscribe to the Special Data Dissemination Standard (SDDS) or participate in the General Data Dissemination System (GDDS) are especially useful to this end. The SDDS, for instance, is designed specifically with attention to the requirements of international capital markets. Countries subscribing to the SDDS commit themselves to publish data according to a standard format, and to explain their data dissemination practices. If, instead, a country is participating in the GDDS, it commits itself to publish its statistical practices, along with the plans for improving them. The World Bank Group also provides technical assistance and loans for improvement and development of national statistical agencies in emerging countries. Secondly, sovereign debt does not have to be linked to a variable under direct control of the debtor. It is possible to choose a reference rate for the warrants that is published by third party, e.g. an international organization. Alternatively, the warrant may include a provision defining its underlying variable as the bigger of two rates – one published by the country and the other by a third party. In this way, the country's government will not have an incentive to misreport GDP growth, and at the same time there will be no dependence on a third party.

There is also a case in practice that shows that statistical agencies are able to gain the trust of the investor community: CPI-indexed bonds are widely accepted in many countries, including developing ones. It can be argued, of course, that it is harder to calculate GDP accurately than to measure consumer prices. Nevertheless, the case of CPI-indexed bonds demonstrates that the market would not necessarily collapse even when there are problems with reported economic data. In Brazil, during a period of high inflation (1970s and early 1980s), the government modified published inflation indices and bond indexing rules several times. The market, however, survived: investors set up an alternative inflation

measure that since then has served as the reference index for government inflation-indexed securities (Borensztein and Mauro, 2004).

- **Moral hazard** Another problem, connected to the previous one, is that governments, even if they do not unduly influence the reporting of macroeconomic variables, still have indirect control over these variables through their policies. The use of GDP-linked debt could then give the government an incentive to avoid growth-oriented policies. GDP-linked bonds would increase payments when GDP growth is above a certain threshold, and thus they could reduce the issuer's incentives to grow. In such case GDP-linked debt would rather stimulate inefficiency than bring benefits to the debtor countries. Ultimately, however, a country's growth rate is determined by decisions in private sector, which would not restrict its development because of indexation of the public debt to GDP. The moral hazard problem, if it occurs, would thus influence the country's performance only partially – through government policies that affect the growth rate, e.g. public investment. Whether the use of GDP-linked bonds would make a government to change its attitude towards growth-oriented policies is still an open question. It is useful to note, nevertheless, that the political argument used for the previous problem applies to the moral hazard issue as well: politicians have strong incentive to follow pro-growth policies to become re-elected, to gain popularity, etc. Moral hazard can also be avoided through a credible commitment to good policies, e.g. in the framework of an IMF-supported program or an international agreement that imposes fiscal rules and peer monitoring, such as the SGP of the European Union.

Interestingly, a recent study by Cordella and Levy Yeyati (2004), although focused on exploring the incentive effects of country insurance schemes such as an expected IMF bailout, finds that such schemes, especially when contingent on negative external shocks, are more likely to encourage rather than to deter reform efforts in volatile economies subject to frequent crises. According to the results of the study, country insurance actually reinforces reform incentives, despite the presence of moral hazard, by increasing the political returns on the reforms through several channels. The study also finds that the mechanism is especially effective in the case of 'enhancing' reforms, i.e. reforms that have higher payoffs in the absence of crisis, such as growth-oriented long-term policies. Hence, to the extent that GDP-linked debt provides insurance benefits to the issuer, these benefits may mitigate the problem of moral hazard.

- **Role of defaults** The benefit of reducing the likelihood of defaults has a potential shortcoming. The elimination of default costs may remove the main mechanism that is acting to prevent the defaults themselves. Dooley (2000) suggests that temporary but substantial losses in output, which typically follow after financial crises in developing countries, act as an incentive for the repayment of external debt by sovereign borrowers. On the other hand, he also acknowledges that default costs have not been completely successful in encouraging sovereign debtors to repay. Additionally, these costs may be too high and traumatic for the economy to be regarded as a mechanism of ensuring debt repayment. Sovereign defaults typically lead to a number of severe and distressing consequences for the debtor country, including the loss of access to international capital markets, long-term increases in borrowing costs, harmful effects on trade, widespread bankruptcies, sharp declines in real wages and job losses, debt overhang, suspension of foreign direct investment, and capital flight. A model constructed by Borensztein and Mauro (2004) also shows that when GDP-linked debt allows avoiding the inefficiencies associated with formal default, the borrowing country obtains additional benefits in terms of higher investment.
- **Choice of underlying** Since one of the benefits of indexed debt is to maintain debt sustainability, an issuer with this objective in mind would choose an underlying variable that makes interest payments to adjust to repayment capacity in the best possible way. Such variable may as well be the value of the country's exports, rather than GDP. In fact, the value of exports is the ultimate indicator of repayment capacity. As such, it would make sense to index debt to exports. This structure has additional benefits: the data on exports is more reliable than GDP in many developing countries and, beside this, it can be verified on the accounts of the country's trading partners. On the other hand, international trade may be affected by government policies more directly than GDP, so the use of export-linked bonds would increase the risk of moral hazard. At the same time, GDP is the most comprehensive measure of country performance, which accounts for the contribution of exports as well, so it is, on balance, preferable as the reference rate for the indexed debt.

Another alternative, applicable mostly to developing countries, is to index sovereign debt to commodity prices, as suggested by several researchers and tested in practice.⁴² This method has an advantage, since commodity prices are outside the control of the debtor country's government and are reliably measured. The structure would make sense for small countries, where commodity prices determine national incomes to a large extent. The revenues of most larger countries, on the other hand, are not dependent on the price of a single commodity. In fact, one commodity accounts for more than 25% of exports in only 6 of 27 developing countries, for which data are available (Borensztein and Mauro, 2004). Furthermore, there already exist developed markets for commodity futures and options that may be able to cover the hedging needs of investors and exporters. Another argument against the use of commodity-linked debt by developing countries is that it would be preferable to establish a market for bonds linked to a single type of variable. Such single market would be more likely to create a dedicated class of traders and investors, thus promoting liquidity, and would permit more efficient international risk sharing.

- **Data revisions** Macroeconomic data is often subject to revisions even in advanced countries. For GDP, in particular, such revisions may be even larger than for other variables such as CPI. The inaccuracies in GDP estimates could be a source of concern for investors, but should not represent a big issue. If the bond contracts clearly state the way the revisions will be dealt with, investors would not probably be concerned about them at all. For example, the terms and conditions may specify that only the final release is taken into the account, or establish a certain date of settlement, after which the revisions are to be ignored. Over a long period of time (e.g. ten years) the data revisions may actually cancel themselves out, reducing the impact of this problem on the overall performance of the GDP-linked bonds. Borensztein and Mauro (2004) studied quarterly GDP revisions on the case of Argentina during 2Q1999-1Q2003 and found that the revisions were relatively small, even though the sample period included times of major uncertainty and a collapse of the economy: the largest one amounted 1.2 percentage points while the GDP growth rates ranged from -16.3% to 5.4%. Still, from the point of view of the debtor country, it may be

⁴² Commodity-linked bonds were proposed generally by Kletzer et al. (1992), Haldane (1999), and for the case of Chile by Caballero (2002). Several countries, including Mexico, Venezuela, Nigeria and Uruguay, issued commodity-linked bonds in the 1990s.

not advantageous to use preliminary GDP data as the underlying variable for GDP-linked bonds, since its inaccuracy may reduce the benefits related to the role of indexation as an automatic stabilizer.

- **Reporting lag** The functioning of the GDP-linked bonds as automatic stabilizers also depends on the extent to which the variable part of coupon payments follows the economic cycle of the debtor country. GDP data, typically, becomes available with a time lag. Thus, the additional payments may fall on a period when the economy has started to decline, exacerbating the economic difficulties. While still a possibility, this concern is reduced if the bonds are indexed to the quarterly GDP instead of the annual data. The autocorrelation of quarterly GDP data is typically high, as recessions and recoveries tend to last at least several quarters. At the same time, the data publication lag is not excessively large even in developing countries: quarterly GDP becomes available after approximately three months. Moreover, GDP-linked debt as an automatic stabilizer would probably be more effective in any case than discretionary fiscal policy. Another concern is that the debtor country may delay the reporting of the underlying variable in an attempt to avoid or postpone additional payments. Such behavior may be prevented in the same way as data misreporting, or by establishing a penalty for failing to provide the GDP data in a timely fashion.
- **Complexity and pricing** Some investors may be turned away by the complexity of GDP-linked bonds. Their complexity, however, should not be overestimated. As noted above, the structure of these bonds is, in fact, similar to a conventional floating rate bond or a bond with an attached warrant, depending on the variant of the indexation formula. Indexed bonds are quite common in corporate and government debt markets in both advanced and developing countries. The pricing of GDP-linked bonds, however, is an open question, considering the nature of their underlying. Still, the absence of a commonly accepted, straightforward pricing formula does not preclude the market for such bonds from succeeding. In fact, markets for common derivative instruments had developed well before modern pricing tools were designed for them.
- **Political incentives** An obstacle to adoption of the GDP-linked bonds may emerge also from the issuers' side. Such obstacle is inherent in the system of political decision-making. GDP-linked bonds would bring benefits to the debtor country only if they have sufficiently long maturity – perhaps, longer than 5 years. The politician's horizons, however, are

typically shorter than that. In case the country is constrained to pay a premium for GDP indexation of its debt (e.g. due to limited liquidity), the present government will have to commit to paying the premium for the benefit of future governments. From the perspective of the public choice theory, the government would have no incentive to do this. On the other hand, Cordella and Levy Yeyati (2004), building on their proposition that country insurance is actually reform-inducing, argue that a government will always be willing to purchase such insurance at a fair premium, since it would increase the government's utility relative to the no-insurance case.

Additionally, there is an issue related to potential additional payments: it may be difficult for the government to justify paying a premium or higher coupon payments in times of good performance. This is a similar consideration to the one for the corporate setting, as demonstrated by Hull (2003), who provides an imaginary but not unrealistic discussion between a corporate treasurer and the president. The only solution to this problem, if it arises, seems to be to ensure that the members of the government and the public fully understand the hedging mechanism of GDP-linked debt and its benefits.

- **Call features** The callability of sovereign bonds is unlikely to be compatible with GDP indexation as the call feature effectively denies the investors any upside the indexation might provide. If the GDP-linked bonds were callable, it would be reasonable for the issuer to call the bonds before the exercise of the warrants (or above-average payments in case of the floating formula). The reason for this is that in times of better economic performance of the debtor country the yields on its debt would fall, and the country would rather refinance itself at the lower interest rates than pay additional coupon payments. Such a scenario is easily identifiable, yet it was ignored in the design of the Bulgarian GDP-linked bonds described in 3.2.2. The Bulgarian issue had been, in fact, called before any additional payments became due.

Borensztein and Mauro (2004) estimate that at present less than 5% of sovereign bonds are callable, so there is no significant obstacle to issuing GDP-linked debt in this sense. On the other hand, the call feature is in itself a form of insurance of the issuer against adverse changes in the interest rates. In this context, the decision to issue GDP-linked bonds may have to be taken in the frame of the trade-off between obtaining protection against changes in interest rates and stabilizing the debt-to-GDP ratio.

To sum up, issuing GDP-linked bonds appears to be beneficial to sovereign borrowers. While it is acknowledged that there are several problems associated with this type of debt, none of these obstacles seem insurmountable. This raises the question why these bonds have not gained popularity on the market yet. The answer may lie in the barriers to the financial innovation in general, as outlined in 2.2.3: it may require some effort for these instruments to gain widespread acceptance. The next section attempts to explore why the market would, indeed, want to accept GDP-linked bonds.

3.2 GDP-linked bonds from investor perspective

3.2.1 *Benefits to the investors*

GDP-linked bonds can be viewed not only as an instrument beneficial to sovereign issuers, but also more generally as a means of international risk sharing and a way of minimizing the risk of disruptions associated with debt crises. Yet in order to succeed in this role, GDP-linked bonds would have to be accepted by the market. This subsection suggests some of the potential benefits of GDP-linked bonds to international investors.

- **Diversification opportunities** As GDP growth across the world is far from being perfectly correlated, GDP-linked bonds would provide an appealing diversification opportunity. A simple exercise on a sample of 15 countries illustrates the point. A correlation matrix of the real GDP growth rates over the period 1961-2003 based on the data from the World Development Indicators Online reveals that of 105 unique cross-country correlations only 16 exceed 0.5 (the correlation matrix is provided in the Appendix, Table A.5). Figure 4.4 also demonstrates the results on a correlation map, where the variables are rearranged according to their similarity.

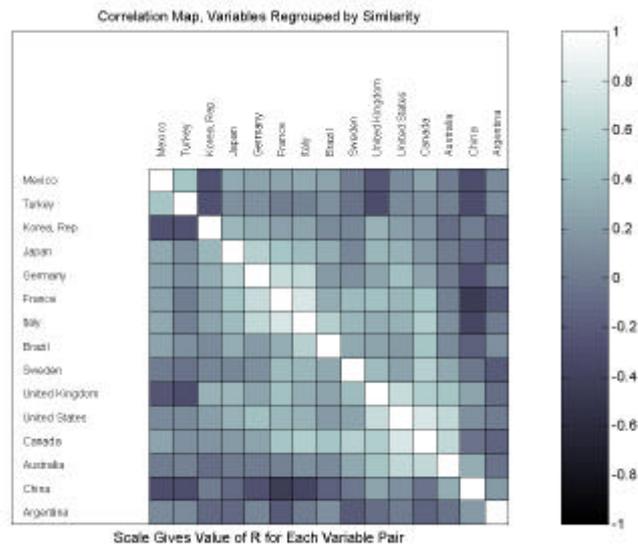


Figure 3.4 Correlation map of real GDP growth rates for 15 countries over 1972-2003

Source: World Development Indicators (WDI) Online, World Bank, <http://publications.worldbank.org/WDI/>, accessed 04/04/2005; author's calculations.

Borensztein and Mauro (2004) reach similar conclusions on the data reported by 27 advanced countries, 39 emerging markets (classified as such according to the IFC definition), and 26 relatively large developing countries. They perform regressions of individual countries' real growth rates during 1970-2001 on world GDP growth and find that unsystematic variation is far larger than systematic variation. For emerging market countries, the average R^2 amounts to 0.10, with a minimum of 0.00 (Argentina, Bulgaria, and some others) and a maximum of 0.39 (Botswana). For advanced countries, the R^2 is higher, but only marginally (0.28). If the individual growth rates are regressed on the US GDP growth, the coefficients of determination become even smaller (0.03 for emerging market countries and 0.14 for advanced countries). For bonds, Solnik et al. (1996) find that the correlation of monthly U.S. bond returns with dollar bond returns in Germany, France, UK, Switzerland and Japan over December 1959-November 1995 was on average 0.18.⁴³

As long as the countries' growth rates are not perfectly correlated and investors desire to smooth their consumption over time and across states of nature, they would then appreciate

⁴³ The same study also finds that the correlations between stock and bond markets rises during the periods of high volatility. However, even in these periods international correlation remains at levels that still make diversification beneficial.

the opportunity to invest in assets with returns linked to other countries' GDP. Ultimately, of course, the additional diversification benefits of the GDP-linked bonds, or the warrants stripped from them, would be determined by their potential to improve the currently available investment opportunity set and by their performance relative to specific investors' portfolios, which can be evaluated, for example, with 'spanning' tests or other performance measure.

- **Avoidance of losses** GDP-linked debt would lower the frequency of debt crises, which often lead to costly litigations and renegotiations. The associated costs and losses may be significant even to large private financial institutions that supposedly diversify their risks well. A default is usually followed by disorderly liquidation of the borrowing country's debt by some investors, which take significant losses on selling the distressed debt. However, in some situations even such limited recovery of investment is not possible. For example, in the immediate aftermath of Russia's default in the summer of 1998, the obligations of some countries could not be sold at any price for several weeks (Granville, 2002). Some commentators even argue that after the recent restructuring of the Argentina's debt creditors may expect to lose in general as much as 70% in sovereign debt crises.⁴⁴ Moreover, chaotic default processes create considerable uncertainty over the recovery values, and risk-averse investors should prefer to receive lower interest payments at times of below-average performance, as agreed upon in the bond contract from the outset, rather than face an uncertain restructuring process.

A study of the magnitude of the losses suffered by the private sector was undertaken by Klingen et al. (2004). They find that the average return to creditors in emerging debt markets during the period of 1970-2000, which included two major sovereign debt crises, was about 9% p.a., about the same as the return on a 10-year U.S. government bond over the same period. The result also holds case-by-case for most of the largest borrowers. This means that the creditors did not earn almost any risk premia *ex post*, even though they had taken on considerably larger expected risks *ex ante*. Klingen et al. (2004), however, contend that creditor banks withstood the 1980s debt crisis reasonably well. Yet if GDP-

⁴⁴ "Argentina sets a dangerous precedent: The IMF should set tough conditions for further lending", *Financial Times*, 07/03/05.

linked bonds were issued instead of conventional bonds, the return on the developing countries' bonds could be closer to fair.

It is sometimes also argued that the private sector was effectively 'bailed out' in a number of episodes (e.g. Turkey and some Asian countries) by official lenders through their support of the borrowing country, implying that the potential losses of the private sector should not be a concern as long as an official bailout is expected. However, the efficiency of this solution remains questionable, as it raises the risk of moral hazard on the part of the debtors and conflicts with the mandate of the sponsors of bailouts – governments and international financial organizations.

- **Opportunities for position taking** GDP-linked bonds, or rather, the warrants embedded in them, would provide opportunities for taking positions on countries' future growth prospects. Currently, this is only possible to a limited extent through the countries' stock markets. However, empirical studies find that stock market returns are unrelated to GDP growth. For example, Dimson et al. (2002) show that the correlation between compounded real equity returns and compounded real per capita GDP growth for 16 countries is -0.27 over 1900-2000 and -0.03 over 1951-2000. Similarly, Siegel (1998) finds that during the 1970-97 period the correlation between stock returns and GDP growth was -0.32 for a sample of 17 developed countries and -0.03 for a sample of 18 developing countries. These results apply to aggregate stock market returns. Yet, it is conceivable that there exists a multifactor model with selected assets' returns as independent variables that can sufficiently explain GDP growth, and hence a portfolio of these assets may be used to take positions on the economic growth. However, in many developing countries stock markets are not developed enough to offer such opportunities and are often not representative of the economy as a whole. Thus, investors would welcome the opportunity to express their views on a country's economic growth prospects offered by GDP-linked bonds. This opportunity would be particularly attractive in the case of developing countries, where the stock market is not well diversified.

3.2.2 *Opinions of market participants*

After considering the potential benefits of GDP-linked to investors, it is useful to get an idea of the attitudes of the market participants to these securities. This subsection reports the

results of two surveys of bond market participants conducted by IMF (2004b) and by Schröder et al. (2004).

IMF Survey The IMF survey was distributed among the members of the Emerging Markets Traders Association (EMTA) and the Emerging Markets Creditors Association (EMCA), thus covering market participants both at the ‘buy side’ (e.g. asset managers and proprietary traders) and the ‘sell side’ (e.g. research analysts), as well as ‘cross-over’ investors, who hold emerging market bonds only occasionally (according to perceived profit opportunities), and dedicated emerging market investors. The survey was focused on GDP-linked bonds, but also included questions about potential obstacles to the introduction of the indexed sovereign debt in general. Unfortunately, the response rate of the survey was quite low, so the reported results may reflect a selection bias in favor of GDP-linked bonds, i.e. they may fail to account for the opinions of respondents that generally opposed the idea and, consequently, chose not to complete the survey.

The survey presented a hypothetical case of a developing country, which had been borrowing on the international capital market for a number of years. It was assumed that the country did not experience any major problems related to external debt, but the country’s bonds, nevertheless, traded at substantial spreads above US treasuries. In the example, ‘plain vanilla’ ten-year eurobonds (U.S. dollar-denominated) issued by the country had a coupon of 7% and traded at a spread of 400 basis points over U.S. Treasuries. It was further assumed that the country’s average real GDP growth over the past 15 years amounted to 3% percent, with a maximum of 7% and a minimum of –8%. The average growth and volatility of GDP was expected to be similar in the next decade. The respondents were asked to indicate a premium, which they would require under the above conditions for holding GDP-linked securities rather than plain vanilla bonds with the same expected coupon payment. Two types of the GDP-linked bonds were considered: GDP floaters (type 3.2)) and bonds with embedded GDP warrants (type (3.1)). The suggested formulas for coupon payments were, respectively:

$$c_t = 7\% + \max [g_t - 3\%, 0], \text{ and} \quad (3.7)$$

$$c_t = \max [3.5\% + g_t, 3.5\%]. \quad (3.8)$$

The breakdown of the answers is demonstrated on Figure 3.5. Panel (a) shows that in the case of bonds (3.8) the median premium over plain vanilla bonds was between 100 and 200 basis points. Across investor classes, somewhat higher premia, on average, was indicated by buy-

side respondents and ‘dedicated’ emerging market investors, as compared to sell-side respondents and ‘cross-over’ investors, respectively. Type (3.7) bonds, on the other hand, ensured a minimum positive coupon payment regardless of the economic performance of the borrowing country, and the survey revealed that a lower premium might be required for holding such bonds (panel (b)). The mean premium for bonds with GDP warrants was approximately 100 basis points.

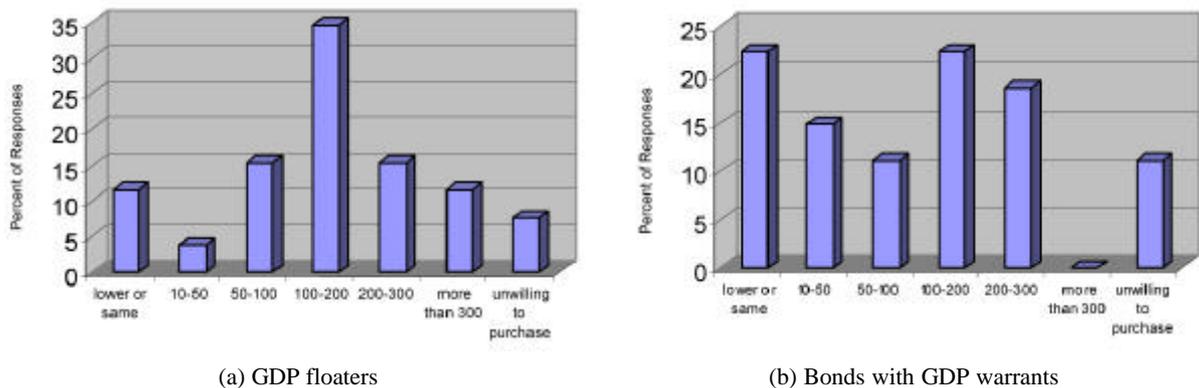


Figure 3.5 Premium over plain vanilla bonds, basis points

Source: IMF (2004b).

The survey also attempted to identify some of the determinants of the premia that investors would require for holding GDP-linked bonds and to measure the relative importance of a number of obstacles to the introduction of such bonds. The results indicate that there are several factors that could reduce the premia required by the investors in the above scenario: (1) issuance of a large volume (>50%) of GDP-linked bonds in the context of a negotiated restructuring of the country’s debt, (2) issuance of GDP-linked bonds by at least five other countries, and (3) evidence of reliability of GDP data reported by the issuers and its monitoring by an international organization. Correspondingly, the uncertainty about the integrity of the economic data reported by the borrower was reported to be the most important concern that made the investors reluctant to hold GDP-linked securities. Other important issues identified were the uncertainty about the future liquidity of GDP-linked bonds and (to a lesser extent) the complexity of their pricing. Understandably, these concerns were more important for cross-over investors than to dedicated emerging market investors.

ZEW Survey The second survey was conducted by researchers of the Centre for European Economic Research (ZEW) and consisted of 21 interviews with potential investors in GDP-linked bonds and financial experts. Respondents represented private and government banks,

investment firms, insurance companies, rating agencies, and tax advisors. The survey covered the following topics: potential users of GDP-linked bonds issued by developing countries, the structure and features of the securities, potential issuers and the development of the secondary market. The main results by topic are reported in more detail below.

- *Potential investors* According to the survey results, GDP-linked bonds would be most suitable for institutional investors such as insurance companies, pension funds, bond funds and hedge funds. The interviewees generally agreed that institutional investors would be able to price GDP-linked debt. It was noted that GDP-linked bonds were not likely to constitute a large part of the portfolio of institutional investors, but rather used for diversification purposes. The most interest in these securities would probably come from hedge funds and emerging bond funds, whose policies and charters allow such investment. These funds might be interested in building short-term or long-term strategic exposures to developing countries through GDP-linked bonds. Life-insurance companies and pension funds, which typically have long investment horizons, might be interested in buying GDP-linked bonds and holding them over the long term in order to hedge the business cycle risk or participate in the growth of rapidly expanding economies. However, there are some criteria that GDP-linked securities have to meet before they are accepted by certain groups of institutional investors. Those funds and firms that focus on advanced market and generally prefer investment-grade securities, might want to purchase some GDP-linked bonds for diversification, but only if these bonds are guaranteed by a trustworthy third party. For example, German life-insurance companies and pension funds could only invest in GDP-linked bonds if they were rated at least at investment grade-level. Some funds may face other restrictions, e.g. they may be required to invest only in instruments with non-negative coupon payments and redemption at par value.

As to private investors, the survey suggests that they are unlikely to invest in GDP-linked bonds directly due to their complexity and difficulties in pricing. In addition, in some countries private investors would suffer from unfavorable tax treatment of innovative financial products. For these products, both coupon payments and capital gains may be taxed, in contrast to straight bonds, which may be subject only to interest taxation when held over a sufficiently long period. Interestingly, the survey speculates that GDP-linked bonds may enjoy demand from investors in Islamic countries. In these countries, charging interest on lending money is typically prohibited, but additional payments of GDP-linked

bonds may overcome this restriction, since these payments would be linked to an operating activity, which is allowed in Islamic finance. The interviews also identified that domestic investors of the issuing countries represent a substantial source of demand for GDP-linked bonds.

Finally, it was suggested that proprietary trading desks at private banks would not be interested in GDP-linked bonds, as they expect their liquidity to be limited. Credit departments, on the other hand, would prefer loan payments to be linked to a specific project performance rather than country performance.

- *Bond structure* The survey contained questions aimed at identifying those features of GDP-linked bonds that would enhance their marketability, but at the same would not unnecessarily complicate the structure of the instrument. The interviews showed that simplicity is crucial for the success of these instruments. The respondents suggested that GDP-linked bonds should be technically similar to inflation-indexation securities, since the latter are already familiar to the market participants. As for the choice of the underlying variable, the respondents expressed a clear preference for linking the bonds to GDP. Additionally, nominal GDP was proposed for debt denominated in local currency, and real GDP for debt denominated in foreign currencies. Regarding possible floors and caps on coupon payments, respondents indicated that a (low) floor would be beneficial for the borrowing countries that are in a stage of poor economic performance, since they would be able to avoid additional interest payments and collect option premiums. However, from the point of view of potential investors, which typically have low risk aversion, coupon floors did not look attractive. Caps on interest payments found no support among the interviewees. The choice of maturity and currency of denomination in general were not considered crucial for the GDP-linked bonds, but the respondents agreed that the bonds' maturity term should cover at least one business cycle (7-10 years). Regarding the question whether GDP-linked debt should be (partially) guaranteed by an international organization, the survey offers different views. A guarantee might be preferable for some investors, which only invest in instruments rated above certain level, and for issuers that are relatively unknown on the international capital markets. On the other hand, a guarantee would reduce the expected return of the bonds and make them less appealing for dedicated emerging market investors, who are willing to take on more risk. On balance, the survey

indicated that a guarantee would be necessary only to the extent it could enhance the marketability of the bonds.

- *Issuers and markets* The ZEW survey was focused on developing countries as the primary group of issuers of GDP-linked debt. Only countries that have high political risks, inadequate institutions or social instability were deemed to be not suited for these securities. The survey suggested, on the other hand, that countries with marginal access to international capital market would especially benefit from issuing GDP-linked bonds, since these instruments may attract some groups of investors that are not interested in straight bonds issued by the country. A greater access to the capital markets would permit the country to build a reputation with investors, and consequently, would open possibilities for issuing other types of securities as well. It was also noted that advanced countries could be potential issuers of GDP-linked debt as well, but may be discouraged from doing so by the higher costs associated with issuing a new financial instrument, relative to offering an instrument of a common type. In general, the survey indicated that the minimum size of the issue for GDP-linked bonds should be €250 million (preferably €500-1,000 million), which may be too large for a single country. If this is the case, the survey suggests that several countries might offer GDP-linked bonds in a consortium. On the other hand, a high volume is not necessary for certain investor groups, such as insurance companies and pension funds. If the issue is targeted at these investors, a low-volume private placement could also be an alternative. The survey respondents agreed that external monitoring of the country-reported GDP data by an international financial institution, e.g. through IMF's SDDS, would be particularly important to increasing the marketability of GDP-linked bonds. Finally, it was concluded that extensive marketing, especially if supported by international financial organizations, would be essential for the success of these securities.

3.2.3 Method for quantitative evaluation

As noted in subsection 3.2.1, in order to evaluate the benefits of GDP-linked bonds from investors' perspective, it is useful to test their performance relative to existing investment opportunities. The following part develops a method for such evaluation and reviews the model used to price GDP-linked bonds in the analysis.

Performance evaluation From a portfolio perspective, an investor with an existing set of risky assets would be interested in adding a new risky asset or a new risky portfolio only if the new investment opportunities improve the performance, or diversification, of his/her existing portfolio. There are several approaches to evaluating the diversification benefits. To evaluate such benefits, Schröder et al. (2004) used an approach suggested by Elton and Gruber (1991) for equity. Their asset selection rule can be generalized as follows: hold an additional set of securities N as long as

$$\frac{\bar{R}_N - R_f}{\mathbf{s}_N} > \frac{\bar{R}_P - R_f}{\mathbf{s}_P} \mathbf{r}_{N,P}, \quad (3.9)$$

where \bar{R}_N is the expected return on the new set of securities and \mathbf{s}_N its standard deviation; \bar{R}_P is the expected return on the existing portfolio P and \mathbf{s}_P its standard deviation; $\mathbf{r}_{N,P}$ is the correlation between portfolios N and P , and R_f is the risk-free rate. This rule expresses the idea that an investor would be interested to buy into assets that have higher excess return than his/her existing portfolio. However, the criteria of higher excess return would be too stringent, since the investor bears only a part of the risk of the two portfolios when they are combined. Therefore, the formula (3.9) includes the correlation coefficient to adjust the required return on the new assets.

The rule (4.9) is forward-looking and requires estimates of expected returns on the two portfolios, their volatilities and correlation, as well as the future risk-free rate. For GDP-linked bonds it would, hence, involve modeling not only the development of interest rates and credit spreads, but also the economic performance of the issuing countries. The performance evaluation undertaken on the basis of such forecasts would rely on multiple assumptions, which would effectively determine the validity of the results. For the purposes of this paper, it may be more appropriate to conduct a backtest by modeling the performance of GDP-linked bonds for a sample of countries, as if they existed over the period studied, and comparing it to the historical performance of appropriate bond indexes. The backtest according to (3.9) would be based on generally available historical data for most of its inputs, except the hypothetical realized returns on GDP-linked bonds. At the same time, the results of backtesting are generally dependent on the developments in the test period and thus may not provide reliable evidence of probable future performance. The hypothetical realized returns for the GDP-linked bonds that would have been realized over the past periods are also difficult to estimate

within this paper, given the limited availability of the data required for the model described below. Nevertheless, it is possible to calculate potential yields (IRRs) on GDP-linked bonds that a country could issue and compare them to the yields on the existing sovereign bonds of the country and thus obtain a sense of how investors might view the new bonds.⁴⁵

It is assumed further that the bonds in this analysis are indexed to GDP according to the ‘bond plus warrant’ formula (type (3.1) with $a = 0$), since it appears more feasible than other forms and has already been implemented in practice. The price of such bonds is taken as the sum of the prices of its components, i.e. the straight bond and a GDP warrant. This allows breaking down the pricing of GDP-linked bonds into two separate procedures: straight bond valuation and GDP warrant valuation.

Straight bond valuation The price of the straight (vanilla) component may be calculated from the market pricing of the existing sovereign bonds issued by the country. This can be conveniently done through a method proposed by Merrick (2004). In his framework, a bond’s current value is a probability-weighted sum of three components: coupon flows, principal repayment and recovery value. The mathematical expression is as follows:

$$V_0 = \sum_{t=1}^T P_t f_t c_t + P_T f_T C_T + \sum_{t=1}^T d_t f_t R, \quad (3.10)$$

where c_t denotes the coupon payment at date t , C_T is the principal repayment at maturity date T , R is the assumed recovery value paid to the bondholder in the event of a default, f_t is the present value discount factor for a cash flow at time t , d_t is the probability of default during the period from $t-1$ to t , and P_t is the probability of timely payment of the promised cash flow at time t . The fixed coupon rate on the hypothetical GDP-linked bonds will be set at a lower level than that of the existing bonds of the issuer, in order to make the price of the straight-bond component consistent with the existing bonds, and 100% principal repayment will be assumed. The risk-free discount factors f_t for each future horizon can be interpolated from the historical US Treasury securities yields $y_{0,t}$ observed at date $t = 0$, according to the following formula:

⁴⁵ It is acknowledged that the yield-to-maturity can be realized only if the bonds are held to maturity and all payments are reinvested at YTM. Clearly, this is not a realistic scenario, however even with this drawback, YTM is still a useful measure for comparing expected rates of return on different investments.

$$f_t = \frac{1}{(1 + y_{0,t})^t}. \quad (3.11)$$

The final valuation component of the model (3.11) is the payments probability distribution. Since a default on a coupon payment leads to the default on all subsequent payments, P_t represents the joint probability of no default occurring from issue date to date t . Similarly, d_t can be expressed by the difference between joint probabilities of no default occurring to dates $t - 1$ and t :

$$d_t = P_{t-1} - P_t. \quad (3.12)$$

The payment probabilities are not assumed to be constant in the model, allowing for time-varying investor perceptions regarding the possibility of default.⁴⁶ The default rates are assumed to have a ‘term structure’, so that the probability of timely payment of a coupon at date t is calculated as:

$$P_t = e^{-d_t t}, \quad (3.13)$$

where d_t is the date 0 continuously compounded term default probability rate for a date t cash payment, defined as:

$$d_t = a_0 + a_1(1 - e^{-t})/t. \quad (3.14)$$

In the above equation, c corresponding ‘short-run’ component.⁴⁷ The three implied model parameters R , a_0 , and a_1 for any day (date $t = 0$) can be estimated by choosing parameter values that minimize the sum of squared residuals for the daily cross-section of conventional bonds actually issued by the borrowing country, while simultaneously constraining the average cross-sectional bond pricing residual (i.e. the difference between the bond’s observed market price and the price generated by model (3.11)) to zero. For GDP-linked bonds, a_0 would presumably be lower than for conventional bonds, so it should be adjusted by a factor l , defined in percentage terms to a_0 . This factor will represent the only crucial assumption in the

⁴⁶ These probabilities are, in fact, adjusted risk-neutral probabilities for risk-averse investors.

⁴⁷ This differentiation is very useful, since it distinguishes the default risk from the credit spread risk. If credit spreads generally widen (e.g. during a crisis), this will be captured by a positive value of a_1 , while a_0 remains the same, reflecting the long-run repayment capacity of the issuer.

valuation of the straight component of the GDP-linked bonds; other parameters will be effectively taken from the actual market prices.

GDP warrant valuation The second component of a GDP-linked bond of the type (3.1) is a series of warrants with annual real GDP growth (as reported by the borrowing country's statistical agency) as the underlying variable and a strike price that will set in line with the historical average GDP growth rate over 15 years, where possible. The GDP warrant presents some challenges in its valuation. As already discussed in 2.1.1, the use of standard option pricing formulas might be questionable in the case of GDP derivatives. Specifically, the Black-Scholes formula will not be used in this analysis for the following reasons:

- The original derivation of the Black-Scholes formula (Black and Scholes, 1973) uses arbitrage arguments, but no arbitrage is possible for the underlying variable of the GDP warrant. Even if there exists a portfolio, which is highly correlated with GDP growth (e.g. one constructed with a multifactor model), this solution will likely be country-dependent and impractical for countries with underdeveloped asset markets.
- An alternative derivation assumes that individuals' utility functions exhibit constant relative risk aversion and that the payoffs of the underlying assets are jointly lognormally distributed with the aggregate consumption (Huang and Litzenberger, 1988). However, annual GDP growth rates do not appear to be lognormally distributed. Figure 3.6 demonstrates the distribution of logarithms of all real GDP growth rates available from the World Development Indicators Online (6,973 observations) and the corresponding normal distribution, making the difference evident.
- The underlying variable does not have observed values between the expiration dates of the warrants. Although GDP data is usually available on quarterly basis, the quarterly estimates do not provide a good measure of the final reported annual growth rate.

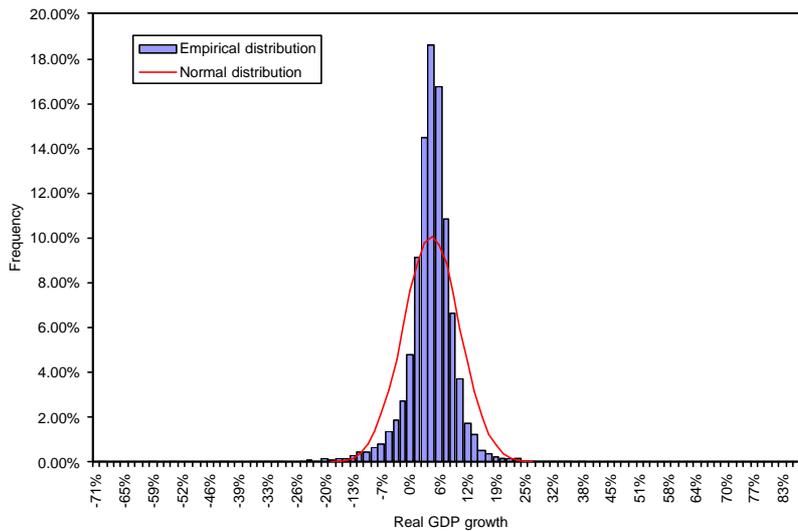


Figure 3.6 Distribution of log real GDP growth rates

Source: World Development Indicators (WDI) Online, World Bank, <http://publications.worldbank.org/WDI/>, accessed 04/04/2005; author's calculations.

- The (undiscounted) value of the warrant may not depend directly on time to expiration. Rather, its value would depend on information available at each point of time. Certainly, it is reasonable to expect that as time of expiration approaches, the amount of information related to the outcome of the underlying variable available on the market will increase. However, the information typically arrives to the market in a random and discrete manner, so market expectations based on the information would also change discretely, and the relationship between time-to-expiration and the GDP warrant value may be less stable than the one typically produced by the Black-Scholes formula, even when discounting effects are excluded.

In view of the above issues, a different approach will be used to value GDP warrants. As noted in 2.3.1, the expected values of the underlying variable on the Economic Derivatives auctions are highly correlated with consensus economists' forecasts (see also tables A.1-A.3 in Appendix). Although this result is based on a very limited sample (approx. 2 years), it only confirms an intuition that the price of a macroeconomic option would depend on the prevailing market sentiment regarding the outcome of the underlying variable. If it is the case, consensus GDP forecasts could be used to estimate the price of an option or warrant on GDP. Such consensus forecasts, based on a poll of private-sector economists, are published on a monthly basis (bimonthly for Central and Eastern European countries) by Consensus

Economics, Inc. A limitation of the *Consensus Forecasts* is that they are available only for the current and the following years' GDP growth, so for the warrants that have a longer time-to-expiration, the GDP growth rate in subsequent years will have to be assumed equal to a long-term average rate (estimated on the previous period).⁴⁸

Certainly, mean GDP growth forecasts published in *Consensus Forecasts* are insufficient for the valuation of GDP warrants – the distribution of the forecasts is also important. However, the distribution of consensus forecasts themselves is unsuitable for warrant pricing, since it does not reflect the distribution of the GDP growth rates. As shown above, the empirical GDP growth rates are not distributed lognormally. Nevertheless, they may be modeled with other distributions that provide a closer match to the empirical one. Figure 3.7 provides an example of such distribution, whose parameters were approximated by minimizing the sum of squared difference between the two probability densities. It is acknowledged that the logistic distribution on Fig. 3.7 underestimates the probabilities in the left tail, but this feature should not bias the calculations, since GDP warrants are, in nature, call options, so with positive strike values only the right part of the distribution will have effect on the warrants' value.

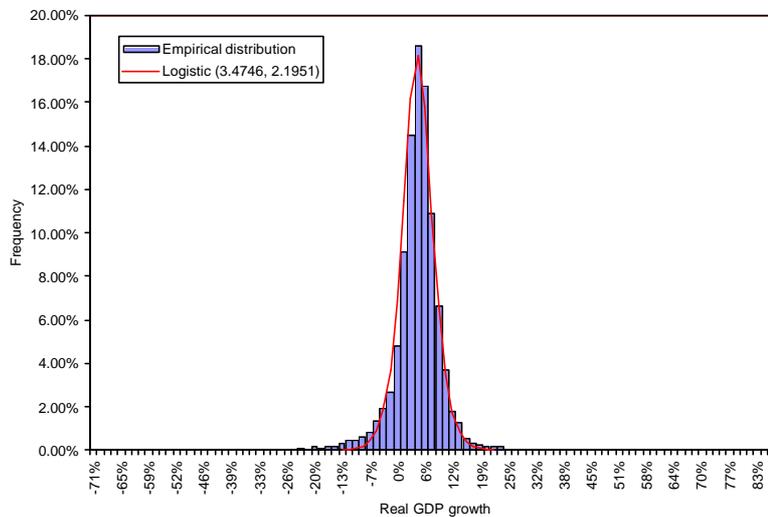


Figure 3.7 Approximation of the distribution of log real GDP growth rates

Source: World Development Indicators (WDI) Online, World Bank, <http://publications.worldbank.org/WDI/>, accessed 04/04/2005; author's calculations.

⁴⁸ Certain sources do provide GDP forecasts for more than 2 years into the future. However, the purpose of this analysis is to determine a 'fair value' for GDP-linked bonds, rather than to price them from the point of view of a single market participant. Hence, only consensus (i.e. average market) forecasts will be used.

The procedure proposed for the purposes of his paper is to use the estimated ‘true’ distribution, with the mean equal to the relevant consensus forecast, for calculating the expected payoff of a GDP warrant, which can then be discounted to obtain the warrant’s value. However, directly using the payoffs based on ‘true’ distribution to calculate the expected payoff and then discounting it by the risk-free rate (the so called ‘actuarial approach’) would be incorrect, since market participants are typically risk averse, and the warrant prices should be based on risk-adjusted rather than ‘true’, empirical probabilities. According to Hull (2003, p. 678), in such cases it is still possible to use the actuarial approach if the underlying variable has no systematic risk. This can hardly be said about GDP growth, so the ‘true’ distribution obtained from historical data and economists’ forecasts needs to be converted into a risk-adjusted distribution. Such conversion may be accomplished with a technique called the ‘Wang transform’ (Wang, 2002). The formula for the transformation is as follows:

$$F^*(x) = \Phi[\Phi^{-1}(F(x)) + \mathbf{I}], \quad (3.15)$$

where $F(x)$ is the ‘true’ cumulative distribution function of the security’s payoff, Φ is the standard normal cumulative distribution, and \mathbf{I} is the market price of risk. Alternatively, the formula may be adjusted for ‘parameter uncertainty’, i.e. for the ambiguity inherent in the estimates of ‘true’ probability distribution, as follows:

$$F^*(x) = Q[\Phi^{-1}(F(x)) + \mathbf{I}], \quad (3.16)$$

where Q is a Student distribution function with k degrees of freedom. The above formula may be, indeed, more appropriate for GDP warrants in the present analysis due to the difficulty of objectively estimating the ‘true’ underlying probability distribution.

The \mathbf{I} parameter is usually calculated as follows:

$$\mathbf{I} = \frac{\mu - r_f}{s}, \quad (3.17)$$

where μ and s are the parameters of the underlying variable and r_f is the risk-free rate. Unfortunately, in this form \mathbf{I} cannot be estimated directly, as the underlying variable does not represent the price of a traded investment asset. For such cases, Hull (2003) suggests using the following equation:

$$I = \frac{\mathbf{r}}{s_m}(\mathbf{m}_m - r_f), \quad (3.18)$$

where μ_m is the expected return on a broad market portfolio (index), s_m is the volatility of return on the index, and ρ is instantaneous correlation between the percentage changes in the underlying variable and the returns on the index.⁴⁹ A weakness of this specification is that it may produce biased values of ρ due to non-lognormal distribution of the underlying variable, although it can still provide an indication of the risk price for the valuation of GDP warrants.

The Wang transform will thus produce a risk-adjusted cdf $F^*(x)$. The expected value based on $F^*(x)$ will represent a risk-adjusted ‘fair value’ of the security at time T, which can be further discounted to time 0 using the risk-free interest rate to give the price of a GDP warrant. As the second component in a GDP-linked bond effectively consists of several warrants with different maturities, its price will equal the sum of the prices of all the warrants. Adding the price of the straight-bond component to this value will give a fair value estimate for the GDP-linked bond.

3.2.4 Quantitative results

This final subsection provides a summary of the results of the calculations according to the methodology described above for several countries: Brazil, Russia, and Italy. It is supposed that each of these countries has issued debt with a remaining maturity of 15 years and with additional GDP-linked payments that are due on 30 April each year if the reported GDP of the previous calendar year exceeds a threshold (the strike price of the embedded warrant). The market value of this debt is estimated as described in the previous subsection and a yield to maturity of GDP-linked bonds is then calculated and compared to yields on the existing sovereign bonds of the country.

Brazil Brazil is one the biggest borrowers among emerging economies and as such represents a good case for the analysis in this paper. Table 3.1 summarizes the analysis of the straight

⁴⁹ The broad market index in this particular case would be better represented by a world bond index, such as the Citigroup WGBI World All Maturities. This choice relies on the assumption that the holders of the GDP warrants would mostly consist of bond investors, and for the bond market, as Ilmanen (1995) shows, the appropriate risk factor is determined by the world excess bond return, rather than world excess stock return.

bond component for Brazil (as at 24/05/05). Parameters used are: $a_0 = 0.1214$, $a_1 = 0.0000$, $R = 76.5054$, $l = 25\%$, and a coupon rate on the GDP-linked debt equal to 6.875%.

Table 3.1 Straight bond component valuation for Brazil

Bond	Market Price	Yield	Model Value	Difference
US\$ 12.75% 15/01/20	131	8.914%	130.14	0.86
US\$ 11% 11/01/12	117.15	7.647%	115.86	1.29
US\$ 7.875% 07/03/15	99.4	7.962%	103.74	-4.34
US\$ 10.25% 17/06/13	114.6	7.776%	114.11	0.49
US\$ 9.25% 22/10/10	109.7	7.057%	108.00	1.70
Model 6.875% 30/04/15	n/a	6.506%	103.12	n/a

Source: Bloomberg, author's calculations. Note: only clean prices are showed.

The average historical GDP growth rate for Brazil based on WDI Online data (1989-2003) is 1.9%, and it is used as the strike of the warrant (the same for each year until 2015) and as an estimate of the long-term growth rate of the Brazilian economy. The consensus forecast for Brazil for the next two years is 3.7% , which gives a warrant value of 11.20% of the bond's nominal value (see Table 3.2).

Table 3.2 GDP warrant valuation for Brazil

Parameter	Value
Strike	1.9% (flat)
Current year forecasted GDP growth (consensus)	3.7%
Next year forecasted GDP growth (consensus)	3.7%
Long-term growth	1.9%
Lambda	0.19
Model value	11.20

Source: Datastream, WDI Online, author's calculations.

The total value of the GDP-linked bond is 114.32, which implies an expected yield to maturity of 6.34%, given the expected cash flows of the straight bond and the attached warrant. The yield of the hypothetical Brazilian GDP-linked bond is, thus, significantly below the yields on other bonds of the same issuer. This is due in part to decreased default risk of the new bonds, which may as well be appealing to certain investors. However, if Brazil were to issue a bond similar to the one assumed in this exercise, it might find difficult to do so in

practice, since the bond's low yield would alienate those emerging markets investors that seek higher returns on their funds. Therefore, in order to make the issue possible and obtain the benefits that GDP-linked debt can provide to the borrower, it might be necessary to offer the warrants for free, i.e. as a 'sweetener', or offer them separately, so that the two components could be distributed among different groups of investors according to their risk appetite.

Russia Russia is included in this analysis, despite potential data quality issues, since it is the most important borrower among the countries with transitional economies. Table 3.3 summarizes the analysis of the straight bond component for Russia (as at 24/05/05). Parameters used are: $a_0 = 0.0625$, $a_1 = 0.0739$, $R = 100$, $l = 25\%$, and a coupon rate on the GDP-linked debt equal to 7.75%.

Table 3.3 Straight bond component valuation for Russia

Bond	Market Price	Yield	Model Value	Difference
US\$ 11% 24/07/18	145.00	6.003%	145.21	-0.21
US\$ 10% 26/06/07	110.88	4.465%	110.77	0.11
US\$ 8.75% 24/07/05	100.82	3.409%	100.72	0.10
Model 7.75% 30/04/15	n/a	4.912%	122.61	n/a

Source: Bloomberg, author's calculations. Note: only clean prices are showed.

The historical GDP growth rate data for Russia available through WDI Online (1990-2003) gives an average of -1.6%, which clearly cannot be taken as a forward projection of the long-term growth rate for the country, since this disappointing performance is largely due to the transition of the economy to the market system. Hence, an assumed long-term growth rate of 4.0% is used as a strike price of the warrant. The 2005 and 2006 consensus forecasts are 5.8% and 5.5% respectively, which gives a warrant value of 11.29% of the bond's nominal value (see Table 3.4).

The total value of the GDP-linked bonds is thus 133.90, which implies an expected yield to maturity of 4.85%, given the expected cash flows of the straight bond and the attached warrant. The yield of the hypothetical Russian GDP-linked bond appears to be broadly consistent with the current yield curve on the Russian sovereign bonds, and thus an investor that has expectations in line with the market would be indifferent between the two types of debt, although he/she might still prefer GDP-linked debt for its (unexpected) upside potential.

Table 3.4 GDP warrant valuation for Russia

Parameter	Value
Strike	4.0% (flat)
Current year forecasted GDP growth (consensus)	5.8%
Next year forecasted GDP growth (consensus)	5.5%
Long-term growth	4.0%
Lambda	0.19
Model value	11.29

Source: Datastream, WDI Online, author's calculations.

Italy Italy is an interesting case for this analysis in light of the benefits that GDP-linked debt can potentially provide to the EU countries, as discussed in 3.1.3. The country is, in fact, one of the largest borrowers of the SGP economies, and it has been suggested that its financial markets might be more receptive to GDP-linked bonds. Table 3.5 summarizes the analysis of the straight bond component for Italy (as at 24/05/05). Parameters used are: $a_0 = 0.0645$, $a_1 = 0.0000$, $R = 100$, $l = 25\%$, and a coupon rate on the GDP-linked debt equal to 5.00%.

Table 3.5 Straight bond component valuation for Italy

Bond	Market Price	Yield	Model Value	Difference
US\$ 4.375% 25/10/06	100.86	3.740%	101.00	-0.14
US\$ 5.625% 15/06/12	108.25	4.258%	108.39	-0.14
US\$ 6% 22/02/11	109.21	4.176%	108.89	0.32
US\$ 5.25% 05/04/06	101.37	3.606%	101.42	-0.05
Model 5.00% 30/04/15	n/a	4.273%	106.17	n/a

Source: Bloomberg, author's calculations. Note: only clean prices are showed.

The average historical GDP growth rate for Italy is estimated on the WDI Online data (1989-2003) at 1.6% and used as the strike of the warrant (the same for each year until 2015) and as an estimate of the long-term growth rate of the Italian economy. The 2005 and 2006 consensus forecasts for Italian GDP growth are 0.9% and 1.6% respectively, which gives a warrant value of 9.31% of the bond's nominal value (see Table 3.6).

The total value of the GDP-linked bonds is 115.48, which implies an expected yield to maturity of 4.25%, given the expected cash flows of the straight bond and the attached warrant. The yield of the hypothetical Italian GDP-linked bond appears to be largely

consistent with the current yield curve on the country's sovereign bonds, as in the previous case, and thus an investor that has expectations in line with the market would be indifferent between the two types of debt, although he/she might still prefer GDP-linked debt for its (unexpected) upside potential.

Table 3.6 GDP warrant valuation for Italy

Parameter	Value
Strike	1.6% (flat)
Current year forecasted GDP growth (consensus)	0.9%
Next year forecasted GDP growth (consensus)	1.6%
Long-term growth	1.6%
Lambda	0.19
Model value	9.31

Source: Datastream, WDI Online, author's calculations.

Summary and conclusions

This master's thesis has presented macroeconomic derivatives as financial contracts with distinctive features and promising applications. These instruments are derivatives linked to a macroeconomic indicator, whose value defines the payoff of the derivative at expiration. Macroeconomic derivatives may be constructed on the basis of common derivative securities or embedded in other instruments. Their underlyings, however, have particular features: macroeconomic indicators cannot be traded, do not allow arbitrage, are reported in a discrete manner, and are 'flow' variables, representing the development of an economic phenomena over past periods of time. Additionally, there are other problems associated with macroeconomic derivatives, e.g. measurement biases and the possibility of misreporting. Due to these peculiarities, the prices of macroeconomic derivatives may behave differently from those of conventional derivatives. For macroeconomic options, this makes the use of standard pricing formulas questionable.

Macroeconomic derivatives appear to have a significant potential. In a wider theoretical perspective, they may help improve risk-sharing in single economies, as well as internationally. In more immediate practice, they can be used for risk management by investors, corporations (under certain conditions), financial institutions, and, ultimately, benefit individuals as well. Additionally, developed markets for macroeconomic derivatives would provide important information for the market at large.

Attempts to implement features similar to those of macroeconomic derivatives in earlier markets were initially unsuccessful. The failures include inflation-linked futures at CSCE in New York, in Brazil and in Chicago, and real estate futures at London Fox. Subsequent related innovations, such as Costa-Rican and Bulgarian GDP-linked bonds, the Michelin credit facility, New Singapore Shares, and contracts on house prices offered by London betting companies, enjoyed more success, but fell short of developing into full-scale markets for macroeconomic derivatives. The major practical obstacles that plagued these earlier attempts appear to be related to a number of issues, including liquidity, measurement and misrepresentation concerns, product uncertainty, reluctance of market makers, coordination problems, and institutional rigidity. These obstacles were subsequently overcome to a large extent in the Economic Derivatives auctions launched by Goldman Sachs and Deutsche Bank

in 2002. The auctions offer short-term derivatives on several macroeconomic indicators, including US GDP growth, and are based on an innovative technology that applies the principles of parimutuel betting systems to financial instruments and provides a solution to some of the most important problems mentioned above, especially the one of creating sufficient liquidity. Other notable recent developments in the field macroeconomic derivatives include inflation futures at CME, new Argentina's bonds linked to the country's GDP growth, house price warrants offered by Goldman Sachs in London, and online retail derivative exchanges.

These initiatives demonstrated, indeed, that macroeconomic derivatives are viable instruments and can deliver their benefits in practice. One of the immediate applications of these derivatives is in the sovereign debt market, where they can offer significant advantages to the borrowers and opportunities to investors. Sovereign bonds can be linked to GDP growth of the issuing countries, creating a combination of a straight bond and a macroeconomic derivative. Such combination has two key advantages: (1) it can lower the likelihood of defaults and debt crises, and (2) help issuers to avoid procyclical fiscal policies. GDP-linked bonds are most beneficial for developing countries, but may also provide benefits to certain developed countries as well. To investors, GDP-linked bonds offer opportunities for diversification and position taking, especially when the derivative components may be separated from the bonds.

GDP-linked debt has several problems associated with it, including GDP misreporting, moral hazard, appropriateness of the underlying, data revisions, reporting lags, complexity of the instrument, and other issues. These problems do not generally seem unsolvable and should not preclude the use of GDP derivatives in the sovereign debt market. Surveys of market participants and a quantitative evaluation of the potential yields on GDP-linked bonds, however, suggest that investors would not universally accept these instruments. According to the pricing model developed in this paper and applied to sample countries (Brazil, Russia, and Italy), in certain cases sovereign issuers may not be able to introduce GDP warrants with their bonds, unless they offer them for free as 'sweeteners' or manage to market them separately to an appropriate investor group. Still, in other cases, depending on the parameters of the bonds and the warrants, GDP-linked debt may successfully replace plain vanilla sovereign bonds, if it promises a yield that is not significantly lower than the yield on comparable existing debt securities, as well as potential upside through the payoffs of the GDP warrants.

Appendix

Table A.1 Results of the non-farm payrolls auctions, consensus forecasts and actual data releases, in thousands jobs

Date	Implied market forecast (IMF)	Median economists' forecast (CF)	Actual release, unrevised
04.02.05	192	190	146
07.01.05	166	175	157
03.12.04	219	180	112
05.11.04	167	169	337
08.10.04	109	144	96
03.09.04	152	150	144
06.08.04	238	228	32
02.07.04	223	248	112
04.06.04	260	216	248
07.05.04	194	173	288
02.04.04	143	103	308
05.03.04	130	125	21
06.02.04	171	150	112
09.01.04	162	130	1
05.12.03	106	150	57
07.11.03	88	58	126
03.10.03	-5	-30	57
05.09.03	8	12	-93
31.07.03	17	18	-44
02.07.03	4	0	-30
05.06.03	-45	-39	-17
01.05.03	-119	-53	-48
03.04.03	-65	-29	-108
06.03.03	-13	-8	-308
06.02.03	59	70	143

Correlations:

CF/Actual	0.628
IMF/Actual	0.664
CF/IMF	0.967

Notes:

In months where two consecutive auctions were held on the same release, only the implied market forecast of the latest auction is taken into account. Consensus economists' forecasts are from the Reuters poll.

Data sources: Reuters News, Goldman Sachs (<http://www.gs.com/econderivs/>), ICAP (<http://www.icapecoconderivatives.com>), Yahoo Briefing Economic Calendar (<http://biz.yahoo.com/c/e.html>).

Table A.2 Results of the ISM Manufacturing PMI auctions, consensus forecasts and actual data releases, percent change

Month	Consensus economists' forecast (CF)	Implied market forecast (IMF)	Actual release, unrevised
02/05	57.0	56.8	56.4
01/05	58.2	58.2	58.6
12/04	56.8	56.9	57.8
11/04	58.0	58.2	56.8
10/04	58.3	58.5	58.5
09/04	60.0	59.4	59.0
08/04	62.0	61.7	62.0
07/04	61.0	60.4	61.1
06/04	62.0	62.1	62.8
05/04	63.0	62.5	62.4
04/04	59.5	59.5	62.5
03/04	61.5	61.1	61.4
02/04	64.5	64.6	63.6
01/04	61.6	–	66.2
12/03	58.1	58.4	62.8
11/03	55.8	56.2	57.0
10/03	55.0	53.4	53.7
09/03	53.5	54.6	54.7
08/03	52.0	51.8	51.8
07/03	51.0	51.2	49.8
06/03	48.5	48.4	49.4
05/03	47.0	47.0	45.4
04/03	49.0	48.1	46.2

Correlations:

CF/Actual	0.953
IMF/Actual	0.969
CF/IMF	0.994

Notes:

Consensus economists' forecasts are from Econoday/Bloomberg/Wrightson-ICAP.

Data sources: Goldman Sachs (<http://www.gs.com/econderivs/>), Bloomberg (<http://www.bloomberg.com/markets/ecalendar/index.html>), ICAP (<http://www.icapecoconderivatives.com>).

Table A.3 Results of the US Retail Sales ex. autos auctions, consensus forecasts and actual data releases, percent change

Month	Consensus economists' forecast (CF)	Implied market forecast (IMF)	Actual release, unrevised
02/05	0.5	0.3	0.6
01/05	0.4	0.3	0.3
12/04	0.3	0.2	0.5
11/04	0.5	0.6	0.9
10/04	0.3	0.3	0.6
09/04	0.2	0.1	0.2
08/04	0.4	–	0.2
07/04	0.2	–	-0.2
06/04	0.5	–	0.7
05/04	-0.2	–	-0.1
04/04	0.6	–	1.7
03/04	0.5	–	0.0
02/04	0.5	0.6	0.9
01/04	0.4	0.4	0.1
12/03	0.3	0.3	0.4
11/03	0.2	0.1	0.2
10/03	0.4	0.6	0.3
09/03	0.8	0.8	0.7
08/03	0.7	0.6	0.8
07/03	0.3	0.2	0.7
06/03	0.3	0.2	0.1
05/03	0.2	-0.1	-0.9
04/03	0.4	0.4	1.1

Correlations:

CF/Actual	0.584
IMF/Actual	0.681
CF/IMF	0.899

Notes:

Consensus economists' forecasts are from Econoday/Bloomberg/Wrightson-ICAP.

Data sources: Goldman Sachs (<http://www.gs.com/econderivs/>), Bloomberg (<http://www.bloomberg.com/markets/ecalendar/index.html>), ICAP (<http://www.icapecoconderivatives.com>).

Table A.4 Simulated growth rates for Figure 3.1.

Year	Scenario	
	Growth declines	Growth rises
0	3.0%	3.0%
1	1.7%	2.9%
2	0.7%	4.3%
3	2.5%	4.1%
4	3.3%	3.0%
5	2.6%	4.7%
6	1.2%	3.9%
7	0.1%	3.1%
8	1.2%	3.8%
9	1.8%	5.4%
10	0.3%	6.8%
11	0.3%	6.1%
12	-0.5%	4.7%
13	0.3%	5.4%
14	0.9%	6.5%
15	0.4%	5.4%
16	0.0%	6.2%
17	-0.1%	5.8%
18	0.0%	5.6%
19	-1.1%	3.1%
20	-1.9%	6.8%

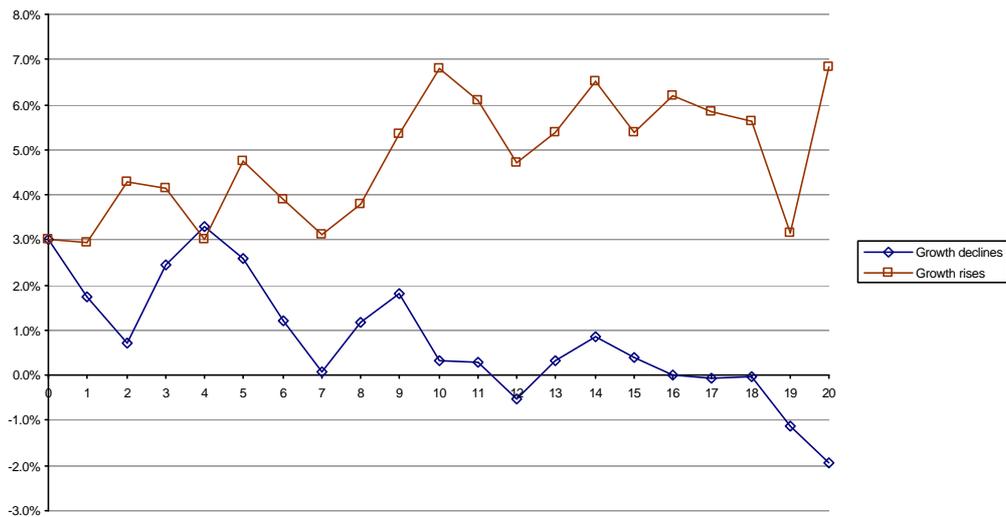


Figure A.1 Simulated growth paths for Figure 3.1.

Appendix

Table A.5 Correlation of GDP growth rates of 15 countries over 1961-2003

	Argentina	Australia	Brazil	Canada	China	France	Germany	Italy	Japan	S. Korea	Mexico	Sweden	Turkey	United Kingdom	United States
Argentina	1.00														
Australia	-0.03	1.00													
Brazil	0.22	0.16	1.00												
Canada	-0.07	0.66	0.50	1.00											
China	0.10	0.12	-0.24	-0.05	1.00										
France	0.04	0.35	0.39	0.50	-0.23	1.00									
Germany	0.09	0.02	0.21	0.25	-0.28	0.66	1.00								
Italy	0.05	0.32	0.55	0.51	-0.46	0.78	0.64	1.00							
Japan	0.11	0.40	0.41	0.30	-0.26	0.75	0.59	0.70	1.00						
S. Korea	-0.05	0.12	0.16	0.28	0.16	0.22	0.33	0.25	0.34	1.00					
Mexico	0.16	0.23	0.26	0.28	-0.11	0.38	0.26	0.34	0.42	-0.16	1.00				
Sweden	-0.02	0.40	0.31	0.47	-0.08	0.61	0.13	0.53	0.48	0.08	0.24	1.00			
Turkey	0.05	0.20	0.19	0.19	-0.17	0.06	0.14	0.05	0.11	-0.11	0.43	0.00	1.00		
United Kingdom	-0.03	0.45	0.22	0.52	0.12	0.36	0.27	0.26	0.30	0.33	-0.07	0.42	-0.18	1.00	
United States	0.04	0.57	0.12	0.75	0.05	0.34	0.45	0.27	0.26	0.19	0.19	0.21	0.10	0.62	1.00

Notes:

Countries are selected according to following factors: geographical representation, volume of external debt securities outstanding, and availability of data.
 Source: World Development Indicators (WDI) Online, World Bank, <http://publications.worldbank.org/WDI/>, accessed 04/04/2005; author's calculations.

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