BROADENING THE APPROACH FOR ITALIAN DEBT MANAGEMENT

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Introduction

In the late Nineties public debt management returned to the spotlight due to the challenges posed by the Maastricht Treaty. Since, Euro area governments have been looking more closely at ways of containing public fiscal unbalances and thus at debt management, which has become crucial especially for largely indebted countries where interest expenditures account for a considerable share of public spending.

For some countries, lowering debt interest costs was made easier by the entry into EMU itself. Indeed, before the Euro advent, countries belonging to the European Monetary System could be split in two groups according to their interest rate levels:

1) the "core countries", e.g. France and Germany,
2) the "high yielders", *i.e.* countries issuing at higher interest rates than the core countries due to both exchange rate and credit risk.

The "high yielders" enjoyed a sudden reduction in interest rates from joining the Euro area, given the vanishing of exchange rate risk and a decrease in credit risk due to an enhanced credibility. The pace at which such a decrease in interest rates materialized into less interest payments depended on the velocity at which the debt was refinanced.

Exhausted the "Euro" effect, countries were left with more traditional ways of reducing interest expenditure. One was that of exploiting the steepness of the yield curve by issuing more short-term debt.[1] However, such a strategy may turn out disastrous for two reasons. First, the expectation hypothesis may prove false: indeed, short-term rates may increase more than what long-term rates initially portend. The failure of the expectations' theory means that intertemporal decisions matters. Hence, shortening maturity exposes debt servicing to greater roll-over risk and eventually to financial instability that, harming credibility, may ingenerate self-fulfilling crises. Secondly, a massive increase in short-term instruments well above investors' demand (supply shock) would trigger an immediate rise in short-term rates[2] that would vanish the expected cost reduction. The unfeasibility of

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[1] See Campbell (1995).

[2] For a thorough discussion, see CBO (1993).

strategies that set cost as the only relevant parameter is at the heart of this work. The focus here is, indeed, to explain that it is risk rather than cost that plays a central role at determining the optimal issuance strategy. Moreover, we will focus on the possibility of setting debt management strategies that look at relaxing budget constraints at times when room for countercyclical fiscal policy is limited as it is nowadays.

1. Private and public debt management: many differences, but same trade-off

How governments perceive risk can be inferred from the vast amount of literature on portfolio management employed by the private sector. However, prescriptions need to be adjusted as to take into account the differences between the public and the private debt managers.

A first difference is that private financial institutions are characterized by a short-term investment horizon together with a very high frequency of both buying and selling operations.[3] The public debt manager has, instead, a much longer-term perspective and participates to financial markets mainly in one way, *i.e.* on the selling side. Therefore, except few buying back or exchange operations, debt managers are bound to the cost undertaken at issuance and bear the risk of future changes in interest rates.

A second difference is that the strategy adopted by the public debt manager differs from that of the private for the budget accounting criteria. Specifically, the latter has a total return approach, while the former measures the cost in real terms.[4] Indeed, despite public accounting is made in nominal terms, debt managers look closely at the trend of the debt ratio, which approximates a measure in real terms.

A third difference is that the public debt manager is not only running the risk of higher debt servicing costs, but also that of impairing the achievement of government's public finance targets with negative consequences for taxpayers. Reducing such risk implies lengthening the effective maturity of debt.[5] However, such strategy may turn more expensive if the expectations theory fails. Indeed, the positive slope of the yield curve can result from an expected increase in higher short- term rates, and also by a premium for higher uncertainty. A trade-off then

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3 This refers to the frequent buy and sell operations of private debt managers who take account of the changing conditions of financial markets. Those transactions are often impossible for the public debt manager mainly because of the consequences they exert on financial markets.

4 Total return calculates the market price variation of both the principal and the coupon of security. Public accounting, instead, considers only the coupons paid and the issue differential (the difference between the redemption price and the issue price. Debt managers are not interested in the change of portfolio's market value due to interest rate variations. In other words, debt managers do not have to mark-to-market public debt. For a discussion, see Modigliani, Baldassarri and Castiglionesi (1996).

5 Confirmation that this risk is crucial for public debt managers stems from the medium/long-term duration of the main OECD debt structures. Some countries explicitly advocate this strategy in their public debt management guidelines (see the Dutch ones of 2002).

emerges between cost and risk: the debt manager can save money by shortening the maturity, but such reduction is certain only for the short-term. Indeed, such debt, in case it has to be renewed at redemption, may be refinanced at higher interest rates than those embedded in long-term rates. It is, thus, only in a context of great confidence about positive primary budget balances in the close future, allowing the repayment of maturing debt, that such strategy would not harm public finances. If governments do not have those expectations, shortening maturity will definitely increase risk.

2. A simple way of identifying the cost/risk trade-off

Among debt managers the most popular measure of risk is Budget-at-Risk[6] (B-a-R), *i.e.* the maximum increase in interest expenditure over a predetermined level in a given period. B-a-R is a function of the debt structure and interest rate volatility. Once the annual target for interest expenditure is set, the job of the debt manager is to limit debt cost fluctuations around that target.

The Italian Treasury used the following as a measure of B-a-R:

$$BaR = D_t \cdot \delta \cdot X_a$$

where:

D_t = stock of debt at time t;

δ = portion of the debt refinanced in one year (principal and coupons) calculated as the reciprocal of the Maculay's duration of the portfolio. In other words, the latter is an estimate of the average portion of debt which matures in a year. More appropriate measures can anyway be used, as the exact amount of debt to be refinanced in a certain period.

X_a= the maximum adverse variation of expected rates in a year which could occur in a given confidence interval, based on the level of present rates. Different interest rate variations can be, of course, considered.

B-a-R methodology may be implemented in different ways. For example, it can be implemented by changing the confidence interval or by simulating the effect of an interest rate shock on individual securities, rather than on the entire portfolio.

Looking at Figure 1, one can see that debt managers should lengthen debt maturity, if they want a lower B-a-R. By doing so, debt managers lock-in their debt at rates for a time equal to the maturity of the securities issued. After the issuance of long-term securities, the only remaining element of uncertainty relates to the financing needed to refund the maturing coupons (unless zero-coupon securities are used).

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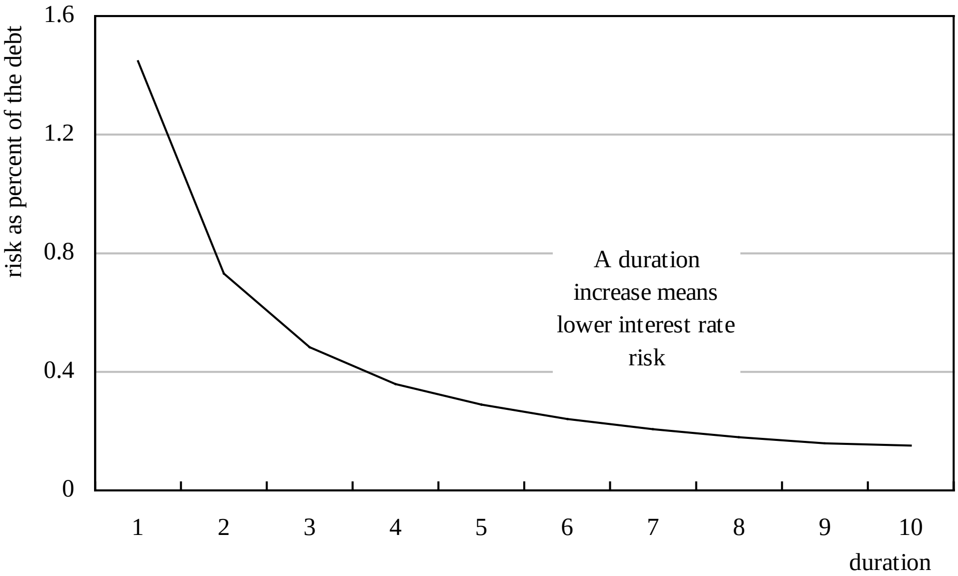
[6] See Pecchi e Scalera (1997).

Figure 1

Budget-at-Risk vs. Duration



The cost associated with long-term issuing depends on the slope of the yield curve. Normally, interest rates increases as time increases: various theories explain why the yield curve is upward sloping. One is that the longer the time for which present consumption is deferred, the higher is the interest rate demanded as to compensate for not disposing the money. Another explanation is that of credit or default risk, *i.e.* the possibility of the debtor to repudiate her liabilities; or the inflation risk as the uncertainty about future purchasing power increases with maturity and a premium to protect from such risk is therefore demanded.

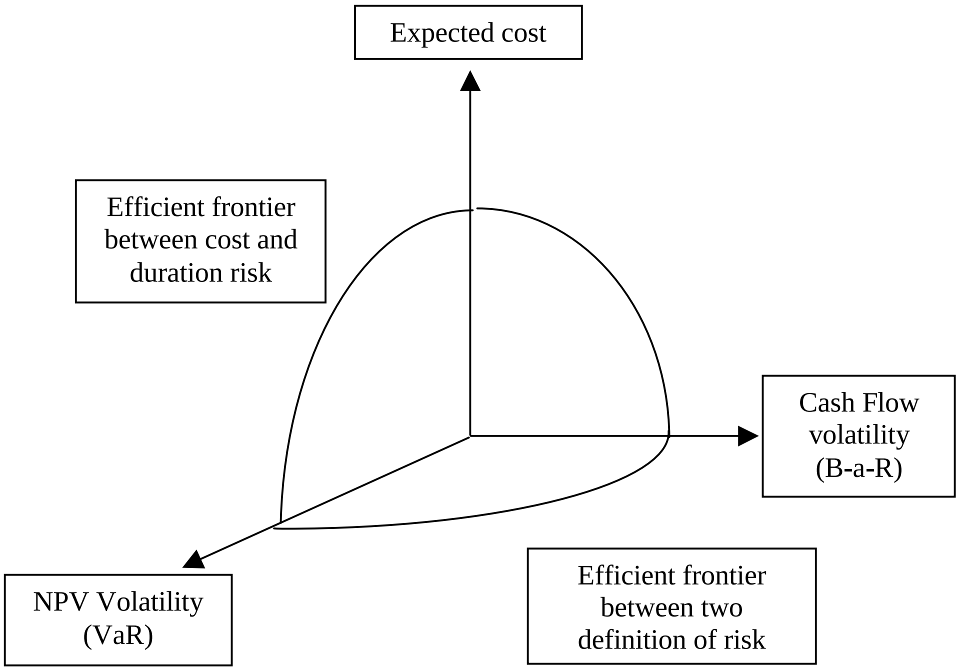
If one were to adopt only the B-a-R rule to determine her issuance strategy, the prescription for the debt manager would be that of issuing exclusively fixed-rate long-term securities. However, issuing these securities inhibits the potential debt servicing cost reduction coming from a lowering of future interest rates.

As to measure such a potential loss, another indicator needs to be implemented beside B-a-R. One could be the market value, *i.e.* the present value of future cash flows. An increase in the interest rate determines a decrease in the market value: the longer the maturity of the instrument, the bigger the loss. This exposure can be measured using the V-a-R methodology.[7] Therefore, if the public

[7] VaR methodology is closely related with the Modern Portfolio theory which measures the trade-off between risk and cost. See also Lamourex e Lastraper (1993), Morgan's RiskMetrics and Bartumek and Mustafa (1994).

Figure 2

Efficient Frontier Defined According to B-a-R and V-a-R Concepts



debt manager were to issue only long-term bonds as to reduce the B-a-R value,[8] the market value of her debt would be very sensitive to variations in market rates (*i.e.* a high V-a-R). A fall in long-term interest rate would increase the market value of debt: the difference between this value and the one prevailing before the interest rate shock represents the "loss"[9] suffered by the sovereign issuer to limit its exposure to interest rate volatility. Setting a ceiling for this "loss" is equivalent to setting a maximum duration for the portfolio.[10]

The use of the two concepts (B-a-R and V-a-R) may be represented in Figure 2.

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[8] See Bohn (1988) for a discussion from a different viewpoint.

[9] The word "loss" is used to highlight the fall in the market value of the portfolio of the public manager. In reality this "loss" indicates that long term securities have been issued at lower than current rates.

[10] For a discussion regarding the definition of the optimal maturity for public debt see Missale and Blanchard (1994).

3. A more sophisticated approach: a predictive control strategy

When using the “B-a-R/V-a-R” approach to define the optimal strategy, the debt manager assumes that the risk embedded in the current structure of the debt is fixed. Hence, such methodology is valid only in the short-term to highlight the trade-off between cost and risk, but looses its attractiveness to define a long-term strategy.

The objective for a debt manager is to minimize some measure of the expected financing cost in the long run while keeping the risk under control.[11] From a pure mathematical point of view, this problem is a stochastic optimal control problem with several constraints imposed by the Growth and Stability Pact (GSP), market practice and the need to control for portfolio risk. Given a system (the outstanding public debt) governed by random forces (interest rates, government borrowing requirement, macroeconomic scenario) the debt manager needs to find the appropriate control (issuance strategy) that optimises her variable of interest (debt cost) over a time interval.

The stochastic components of the problem are represented by the evolution of both interest rates and Primary Budget Balance (PBB).[12] Once a scenario for the evolution of these variables is set-up, the portfolio optimisation may be formulated as a finite dimensional Linear Programming problem, neglecting some non-linear effects of the bond issuances (for instance, a variation of the portfolio composition might, by market reaction, trigger a change in the term structure of the interest rate). By means of standard methods (*i.e.* the simplex)[13] we determine an optimal issuance strategy for each scenario.

3.1 The cost function

The first step of the optimization procedure is to define the cost function to be considered. A reasonable one is the yearly cost of the Public Debt calculated according to the ESA95 criteria.[14]

Roughly speaking, the ESA95 criteria consider for each bond its total cost (coupons plus the difference between nominal value and issuance price) distributed over its existence period, namely, from issuance to maturity. Thus, the cost over a given year is measured by the cost of bonds only for the days that fall within the year considered.

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11 See Bolder (2003).

12 See Maggi, Ginebri and Turco (2002).

13 See Dantzig (1963).

14 See Jackson (2000).

At present, the Italian Treasury issues twelve different types of securities. We order the bond types, according to their maturity, with an integer *k*, taking values in *K*=1,..,12.

Analytically, the ESA95 cost for the time period [t_1, t_2] (where *t* is discrete and corresponds to months) can be expressed as follows:

$$ESA\ 95_{(t_1,t_2)} = \sum_{k \in K} \sum_{t = t_1 - m_\kappa}^{t_2} \frac{u_k(t)}{100}$$
$$\left\{ (100 - p_\kappa(t)) \frac{[t_1, t_2] \cap [t, t + m_\kappa]}{[t, t + m_k]} + \sum_{l=1}^{m_k/6} c_k(t; l) \frac{[t_1, t_2] \cap [t + 6(l - 1), t + 6l]}{[t + 6(l - 1), t + 6l]} \right\}$$

where, for every $t \in [t_1, t_2]$,

$m_k(t)$ stands for the maturity of the k^{th} security (in the formula m_k is divided by 6 as Italian securities pay coupons every six months).

$u_k(t)$ and $p_k(t)$ stand respectively for the nominal amount issued and the issuance price collected, at time *t*, of the *k* type.

$c_k(t; l)$ stands for the coupon percentage at time *t* for the same bond.

3.2 *Interest rate modelling*

The second step of the optimisation procedure is to define one or more interest rate scenarios.

The simplest approach to build an interest rate scenario is to describe the evolution of the short rate only, while a more sophisticated one is to model the whole term structure of rates $p(t, T)$, where *T* represents the maturity.

In the literature, there are a number of possible models for the description of the instantaneous short rate.[15] The most known is the Cox-Ingersoll-Ross (CIR) mean-reverting model.[16] The CIR model is quite simple and it is feasible to apply to a given dataset of the short rate. The results obtained by applying the CIR model to Italian interest rates are contained in James (2000). Since the CIR model has a single factor of uncertainty, it leads to perfect correlation among the bonds regardless of their maturity. It is widely known that, in reality, such perfect correlation is not true.

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[15] See James *et al.* (2000).

[16] The CIR model describes the dynamics of a short rate by a stochastic differential equation as:

$$dr(t) = k(\mu - r(t))dt + \sigma\sqrt{r(t)}dz$$

where *k* represents the speed of adjustment, μ the long-term average interest rate (mean reverting), $\sigma \sqrt{r(t)}$ the implied volatility and *dz* the standard brownian motion.

A more complete description of the yield curve is therefore needed. For instance, we can adopt the Heath-Jarrow-Morton description of the term structure (HJM).[17] Such model considers more factors of uncertainty. It is based on a differential stochastic equation which describes the evolution of the forward yield curve. Since the HJM model could consider several factors influencing the behaviour of the yield curve, it is possible to spot only the main elements driving the evolution of the term structure using the principal component analysis.[18] It is well known indeed that few factors (three can be a good approximation: level of interest rates, slope and convexity of the yield curve) can explain a large component of the volatility structure across maturities, since the forward rates at different maturities are highly correlated.

3.3 The model's constraints

The optimisation process is not free of boundaries: debt managers face a series of constraints when trying to allocate their liabilities. Some of those are "hard constraints" as imposed by law while others are "soft constraints" as imposed by market practices.

In the Italian context, a "hard constraint" is that of maintaining a monthly buffer of 15 billion euro on the Treasury Cash Accounts (TCA) that serve all government's payments and revenues. Another "hard constraint" is that of not overcoming the yearly net issuance amount (*i.e.* the amount that could be issued beyond redemptions) imposed by the budget law. On a supranational level, the "hard constraints" are those imposed by the Growth and Stability Pact (GSP): *i.e.* a debt-to-GDP ratio decreasing at a fast pace to the 60 per cent level.

Among the "soft constraints" a relevant one is that of imposing a minimum outstanding volume[19] for each security issued or, more important, the level of the interest rate risk debt managers are willing to run. Such risk may be measured via the average refixing period (ARP), *i.e.* the average time to maturity of the portfolio with weights proportional to the quantities issued.

3.4 Optimisation and linear programming

We are now ready to start the optimization. We indicate by X_t the total amount of bonds that have not yet matured at time t (*i.e.* the stock of debt outstanding at a certain point in time). Thus X_t must contain, for every $k \in K$, at least one component (*i.e.* type of bond) for every interval $s \in \{t - m_k, \ldots, t - 1\}$. The evolution of X_t is determined, at each step of the optimisation process, by cancelling

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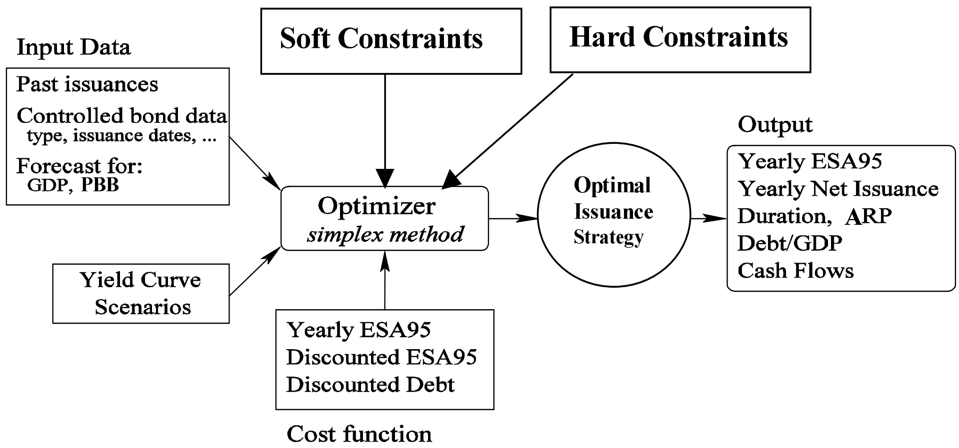
17 See Heath *et al.* (1992).

18 See Avellaneda and Laurence (2000).

19 See paragraphs 5.2 and 5.3 for a thorough discussion.

Figure 3

Block Diagram of the Optimisation Package



the bonds reaching maturity and adding those that have just been issued. For example, for $k = 1$, one has to remove from X_t the quantity of 3-month BOT issued at time $t-3$ and insert those issued at time t. Clearly this can be done by shifting the components of X_t and adding the new issuances.

We can therefore write:

$$X_{t+1} = A\,X_t + B\,U_t$$

where A is a shift matrix, $U_t = ([(u_k(t))/100])_{k \in K}$ is the vector of the new issuances and B is a "sparse matrix".[20] Hence, we get a linear discrete time control system. Eventually, the Optimal Issuance Strategy (OIS), as calculated in the above equation, consists of an optimal control problem with the constraints described in 3.3; the cost function is defined according to the ESA95 specified in paragraph 3.1. Both constraints and the cost function depend on the stochastic exogenous variables $PBB(t)$ and $P(t, T)$.

The block diagram in Figure 3 represents all the phases of the optimisation.

A wide literature for stochastic optimal control problem is available.[21] We *choose to follow a p*robabilistic scenario optimization.[22] With this approach, the generated interest rate and PBB scenarios are given the same probability. Given that

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[20] A "*sparse*" matrix is characterized by a large presence of zero values.

[21] See Yong and Zhou (1999).

[22] For more details see Amadori *et al.*(2003).

interest rate models perform poorly at forecasting interest rate behaviour, we decided that was not appropriate to assign a different probability to interest rate scenarios generated by such models.

The optimiser determines the OIS for each scenario. This is then tested against all the other interest rate and PBB scenarios generated as a measure of risk.

To sum up:

1. The optimiser implements a strategy according to market interest rates.
   a) The model generates *n* interest rate scenarios.
   b) Each interest rate scenario generates an optimal portfolio.
   c) The risk of each optimal portfolio is measured by the variation in cost obtained by running the portfolio on the $n-1$ interest rate scenarios.
2. A "cluster portfolio" is defined in a cost-risk space.
3. The issuance strategies that satisfy the cost/risk trade-off chosen by the debt manager are selected.

At the end of the optimization process the model delivers anyway more than one optimal portfolio, *i.e.* the debt manager has a number of issuance strategies available, all compatible with the constraints mentioned in paragraph 3.3. Which one should be followed?

Beyond the risk/cost considerations previously mentioned, two other factors should enter in the decision process. First of all, a debt manager should consider the interactions between her issuance policy and the secondary market. Secondly, the concept of risk may be enlarged as to consider the budget as a whole.

4. Relevant factors for the choice of an issuance strategy

This section is devoted to all those elements that are impossible to model in a quantitative fashion and on which debt managers spend most of their working time. Those are the organisation and monitoring of both primary and secondary markets and the continuous efforts to smooth and remove market imperfections.

4.1 The primary market

The primary market is where bonds are first generated, therefore an efficient placing of the bonds is of crucial importance for debt managers. Bonds can be either placed via direct bargaining with the counterparts, as in syndicate operations, or via auctions. Different auction methods are available and the design of the optimal method is a key issue for the debt manager.

The Italian Treasury resorts to a discriminatory kind of auction for bills (BOT) as to take into account the rigid demand characterising those instruments. For all the other instruments, instead, the Treasury uses a uniform price kind of auction in order to stabilise demand by reducing the winners' curse. Although, the Treasury can always switch to syndicates if it wishes. The rationale for such flexibility is to exploit at best the distinguishing features of the two alternative methods.

Syndication is, indeed, preferred for the launch of new securities. The bargaining process, a feature absent in auctions, enables the Treasury a better placement as it allows the following results:

- accuracy at determining the interest in the demand for the new instrument,
- large issuance size from the beginning (secondary market liquidity immediately assured),
- a broader distribution and of higher quality: the total control of the book-building process allows the Treasury to have complete discretion at selecting final investors, achieve a satisfactory placement in terms of both geographical distribution and type of investors.

The bargaining process benefits investors as well (and thus the Treasury). Indeed, the possibility of pricing the instrument at its fair value (rather than price being the outcome of a competitive game as it is in auctions) attracts more demand from final investors. Moreover, a syndicated operation, being a one-off decision, creates a "momentum" that is very functional for the good marketing of the new instrument.

On the other hand, auctions are preferred for ordinary debt issuance, being an extraordinary tool for fast and efficient price discovery. Moreover, their simplicity allows the Treasury to easily provide a calendar and hence satisfy two highly desirable needs of the investor community: transparency and predictability.

4.2 The importance of transparency

Transparency is crucial to build investors' trust and thus to lower risk premium. Consider a government that issues for the first time a security promising it will reopen tranches of the same bond so as to assure investors on the future tradability of the specific market. Such promise is more credible if an issuance calendar is out. This enables the government to save on risk premium. Calendars are important for investors who need to plan their investments, especially when they are not aware of the Treasury's financial needs. Calendars, however, limit the scope of tuning the portfolio consistently with unexpected financial and economic scenarios. The trade-off between transparency and flexibility, however, is minor as the information provided concerns only the kind of instruments to issue and not the size. Hence, debt managers are usually prone to run the risk of limited room to manoeuvre.

4.3 The secondary market

Limitations to flexibility also arise when debt managers are committed to a highly liquid secondary market. To build a reputation for high liquidity and, thus, save on liquidity premia, a predictable issuance is needed. Investors should thus rely on the fact that each instrument, before being replaced with an analogous one, will be issued until a liquid amount is reached. Ensuring a high level of liquidity for most of the security's life is crucial for investors as it reduces the possibility of losses when trading. Moreover, large issuance is a necessary but not sufficient condition for secondary market liquidity as this depends also on the nature of allocation made on the primary market. Indeed, if a large volume is allocated to "buy and hold" investors (those keeping the security until maturity), the amount susceptible of trading will sensibly shrink. In other words, before offering an analogous security, debt officials have to ensure that an efficient trading level has been established. No golden rule exists to set the optimal amount. The issuer should reoffer the security whenever its liquidity is showing signs of decline. This requirement alters the issuance policy, as it determines the time during which the bond remains on the run before being replaced. The need to maintain a sufficiently high level of liquidity across time requires a constant effort to monitor market conditions and, if necessary, the possibility to take action to reissue the security.

Liquidity also depends on the efficiency of the secondary market and debt managers, when deemed necessary, can enact rules as to improve this. A secondary market is efficient when transaction costs are low, trading executions are fast, prices are in real time, large volumes are traded, risk of error is small and trading hours allow continuity to the market. The market is transparent when all relevant information are provided in real time (two way prices, volumes traded, purchases and sales).

4.4 The role of "Specialists"

In order to improve both primary and secondary market performance, the Italian Treasury set up a class of Primary Dealers (PDs), so called "Specialists" who, in exchange of some privileges, are committed to a set of obligations. For the primary market, those obligations regard the regular subscription of auctions, whereas for the secondary market, they pertain to the daily trading volume, bid-ask spread and the period at which two-way prices are actively posted. Some of the privileges are granted according to the evaluation Specialists get on the basis of the above parameters. The value of bonds at the auctions, therefore, exceeds their real value, because of the potential profits coming from privileges granted to the Specialists. The opportunity of benefiting from such privileges enhances competition and induces Specialists to have virtuous behaviour. This helps the Treasury at eliminating the risk of auction uncoverage, having a positive impact on issue price, having an efficient and liquid secondary market and, last but not least, having a continuous grasp on financial markets via the day to day interactions with this special class of PDs.

5. Broadening the approach of the debt manager

The PBB enters in the optimisation model as an exogenous stochastic variable as it depends on the evolution of real GDP and inflation. To endogenise this variable, a study was commissioned by the Italian Treasury (see Ginebri *et al*., 2002) with the aim of empirically investigating the historical relation between budget items, real growth and inflation.[23]

The PBB forecast is relevant for the debt manager, not only to figure out what will be the borrowing requirement in the future, but also in case the government wishes to set up a different approach to debt management. Governments can, indeed, give mandate to debt managers to carry out debt portfolio strategies that can help at smoothing taxes or deficit across time. If so, debt managers should structure public debt in order to reduce tax pressure variations (upwards or downwards)[24] or, in case of deficit smoothing,[25] to keep the deficit-to-GDP ratio below a target value (the latter being the 3 per cent for Euro area countries). Debt managers' goal, then, would be not to minimise the cost, but to contribute to the stability of the budget outturn as a whole.

This can be achieved by choosing a set of debt instruments whose interest payments decrease at times of unexpected budget deterioration. If it were possible to index debt interest payments to output or spending (explicit state contingent debt), this would be an easy task to achieve. However, this kind of instruments never encountered the favour of debt managers for moral hazard problems, difficulty of indexation[26] and innovation costs.

The task, in absence of explicit contingent debt becomes very complex. Indeed, replicating the performance of explicit state contingent debt by means of denomination, indexation and maturity of traditional instruments means to correctly forecast the kind of macroeconomic shocks occurring and their impact on the interest rate term structure. The latter is gauged by forecasting the price movements determined by both the macroeconomic shock itself and the Central Bank reaction. If one were to experience a negative productivity shock, *i.e.* a shock where a recession is accompanied by high inflation, nominal long-term debt would be optimal as no roll over is required. This would lead to an overall decline in real debt interest payments. If, instead, one were to experience a negative demand shock, hence deflationary, short-term debt or price indexed debt would be the optimal choice. Deflation, indeed, by pushing nominal interest rates down would make the roll over of short-term debt very convenient.

An optimal hedging debt structure would then be characterized by instruments providing the following covariance:

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[23] See Appendix A for an extended version of this paragraph.

[24] Bohn (1990) and Missale (1997).

[25] See Missale (2001).

[26] See Calvo and Guidotti (1990) and Bohn (1990) for difficulties at implementing such instruments.

- Cov(GDP_t , real interest expenditure$_t$) > 0
- Cov(public spending$_t$, real interest expenditure$_t$) < 0

Given the tight link between GDP and unemployment, thus on tax revenues via tax base reduction and on public spending via the increase in automatic stabilisers, an other covariance proving hedging may be the following:

- Cov (unemployment$_t$, real interest expenditure$_t$) < 0

According to Turco (2001), no countries out of a wide OECD sample exhibited the covariances listed above.[27] Indeed, interest rates seemed to be significantly affected only negatively by inflation and positively by world interest rate. GDP, unemployment and public spending only in few cases turned out to be significant and almost always with the wrong sign. This might reveal either the lack of interest of governments to such goals or the inability of debt managers to accomplish it. The former appears to be the most probable given that in the strategic guidelines for debt management of the main OECD countries, no mentioning is made to tax or deficit smoothing.

6. Conclusions

The very high number of random forces entering debt official's decision process render optimal debt management a very complex task to be accomplished. Indeed, almost all variables relevant to debt managers show to have a stochastic behaviour; to cite a few: interest rates, macroeconomic variables driving the PBB, the domestic and foreign monetary and fiscal policies and their inter-connections.

The long-term horizon, peculiar of public debt management, makes the job of the debt manager even harder, given that the probability of bad forecasting increases with time. Models can help at forecasting, but they cannot capture all the elements debt managers need to face. This does not mean that they are useless, on the contrary they represent valuable inputs.

Therefore, the debt manager cannot stick to a single model as a solution to her problem. She needs to interpret all of the models' outcomes at her disposal and combine them together with the information flows she receives. Moreover, caution at choosing a strategy is imperative, because of market practice constraints (market oriented strategy). Market constraints do not allow the Treasury to implement such strategy as this implies a frequent change of the issuance policy. This is, indeed, unfeasible as it is in conflict with the regularity and the transparency needed by investors to invest in Italian securities (so called market oriented approach). Finally, debt managers need also to consider that their actions not only produce effects on financial markets, but have also great welfare implications. It is therefore recommended to consider, beside optimisation models, more qualitative aspects that can only be grasped and tackled by debt managers directly via their experience and sensibility.

[27] See Appendix B for an extended version of this paragraph.

APPENDIX A[28]

THE SENSITIVITY OF THE ITALIAN PRIMARY BUDGET BALANCE TO INFLATION AND OUTPUT

Budget evolution depends on both the economic cycle and the fiscal policy actions implemented by the government and the interrelations between the two. Each item of the budget can, indeed, be disentangled into an automatic and a discretionary component. The latter depends on a specific decision of the policy maker and, therefore, is completely under her control. The automatic component, on the contrary, hinges on predetermined rules set up by the policy-maker and therefore varies inertially according to macroeconomic conditions. A more accurate study on the Italian case is that commissioned by the Italian Treasury (see Maggi, Ginebri and Turco, 2002) where the sensitivity of the Italian Primary Budget is estimated to both real growth and inflation via a strong budget itemization.

The methodology used is straightforward. First, when possible, a macroeconomic base was associated to each public finance item, typically a tax base for each tax. Second, each tax base was regressed on the driving economic variables, *i.e.* real growth and inflation. Third, each item of the government budget which were supposed to include an automatic component was regressed either on its own base or directly on the economic variables affecting the automatic components.

As a consequence of the estimation strategy, the elasticity of the government budget to macroeconomic variables will typically be the product of two coefficients: the elasticity of each public finance item to its own base and the elasticity of the base to the driving economic variables.

As reasonable as the estimation procedure can be, it contains a major drawback. It correctly identifies the automatic component, provided that the discretionary component is independent on the core macroeconomic variables. However, that is a binding assumption. The discretionary component expresses the policy-maker preferences, and those are probably related to the macroeconomic conditions. As a consequence, the estimated elasticities of government budget capture both its automatic component and the policy-maker reaction function to macroeconomic variables.

The knot between automatic component and policy-maker's reaction function is, evidently, more relevant in the case of expenditures: public investments, transfers to households and companies, public wages and employment. Even in the case of revenues, some overlapping between them occurs. However, the frequent reforms of fiscal laws and rules occurred in the last 30 years, rendered prohibitive the removal of the effects of those from the time series and therefore the isolation of the automatic components from the political reaction function. Anyway, despite elasticities do not exactly identify the automatic component, elasticities still measure

[28] This appendix is extracted from Maggi, Ginebri and Turco (2002).

the relationship between macroeconomic aggregates and government budget. On those grounds, elasticities were also estimated for the expenditure items whose discretionary components are larger: public consumption and wages, investments, transfers to companies were therefore estimated. The use of estimated coefficients has to be cautious. If interested only to the automatic reaction of government budget to the economic cycle, then overall budget sensitivity is that arising from the items whose components are strictly automatic: most of revenues, unemployment benefits and pensions. While, if interested in the budget reaction when also not strictly automatic expenditures are included, results (see Table 1) show indeed semi-elasticities to reduce consistently. Indeed, the impulse of both inflation and real growth on public finances appears to be positive, but when public consumption, investment and transfers to both private sector and households are included, this decreases dramatically to reach almost zero when the reaction to inflation is examined. This is due to the fact that pensions enter in the estimation only when inflation sensitivity is estimated, being those indexed to consumer price index. The strong dynamics of the time horizon stem from the advance and balance mechanism of some taxes (e.g., tax on business profits-Irpeg).

Table 1

Semielasticities of the Primary Budget
with Respect to Inflation and Real Growth*
(percent of GDP)

		t	*t*+1	*t*+2	*t*+3	*t*+4
Strictly automatic	Inflation	0.18	0.27	0.18	0.17	0.18
	Real Growth	0.33	0.42	0.32	0.30	0.31
All components	Inflation	0.01	0.10	0.00	–0.01	0.00
	Real Growth	0.16	0.24	0.14	0.12	0.13

* Semielasticity stands for the change of the primary budget ratio for a 1 per cent change of inflation/real growth.

The great difference between the first and the second row figures point to the delicacy of the issue. Strictly automatic figures are more reliable as they only identify the reaction of automatic components, but less comprehensive as they leave almost all of the expenditures out.

APPENDIX B[29]

DID TAX SMOOTHING OR DEFICIT SMOOTHING EVER DRIVE DEBT MANAGEMENT POLICIES?

In order to answer this question, a time series analysis was run for a sample of 16 OECD countries (Austria, Belgium, Canada, Spain, Finland, France, Germany, Ireland, Italy, Japan, Netherlands, Norway, Portugal, Sweden, UK and United States), the specification being the following:

$$d(ra_t)=\alpha_t+ \beta\ ln(GDP_t/GDP_{t-1})+ \varepsilon_t \qquad (1)$$

$$d(ra_t)=\alpha_t+ \beta\ d(ur_t) + \varepsilon_t \qquad (2)$$

$$d(ra_t)= \alpha_t+ \beta\ d(spt)+ \varepsilon_t \qquad (3)$$

The dependent variable ra_t stands for the average annual real interest rate paid on debt, calculated as the ratio between debt interest payments (on a cash account basis) at time t and gross debt at time $t-1$ minus the change in the consumer price index at time *t*.[30] Since gross debt figures refer to the end of the year, rather than an yearly average, it was preferred to consider the interests paid on inherited debt, rather than actual debt. The rationale for this was to avoid situations where debt variations are accounted while corresponding movements in interest payments not yet.[31]

With regards to the independent variables instead:

- GDP_t stands for the volume of gross domestic product at market prices.
- sp_t stands for the ratio between current government disbursements excluding interests and the value at market prices of gross domestic product.
- ur_t stands for the unemployment rate.

Differences for both dependent and independent variables are taken to avoid problems of non-stationarity. The regressions, whose Durbin-Watson test delivered

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[29] The appendix is extracted from Turco (2001).

[30] The analysis could improve if a different inflation measure than *cpi* is implemented. The latter is indeed inefficient as a relevant measure for inflation when assessing the impact price movements exert on government budget. *cpi* is probably not a reasonable price index to measure real term costs for government debt. The latter is indeed designed as a compensation index to measure how the capacity of a representative household is affected by general price changes. If, instead, the aim is to measure in a corresponding way how the government's real costs are affected by inflation, the relevant index must have a structure equivalent to that of the government's price level-dependent expenditures. However, when assessing risk, it would be misleading to consider Government consumption price index. Indeed, the Government has other kind of expenditures that are dependent on other price levels, especially transfer payments. The same applies to Government income, especially tax revenues. The Government should then spot an ad-hoc price index that better captures the effects of price movements on public budget as a whole.

[31] This is the case for zero coupon bonds which determine an increase in debt stock at issuance but have their interest payments accounted only at maturity date.

insufficient values, were run again with an autoregressive term. Endogeneity may be a problem given that real interest rates do play a role at explaining movements in the independent variables. However, this problem arises only when our independent variable ra_t (being calculated as the ratio between debt interest payments and gross debt) performs well as a proxy for real interest rates, *i.e.* when debt maturity is short.

For the debt structures to provide insurance then, we expect coefficients to be positive for *GDP* and negative for both *sp* and *ur*. However, very few regressions were significant[32] and all presenting a non-hedging sign. The poor explanatory power of the regressors points directly to the scarce consideration of debt managers at providing a procyclical behaviour to debt structures.

Given the poor performance of the variables above, other specifications were tested in search for more explanatory factors:

$$d(ra_t)=\alpha_t+ \beta\, d(cpi_t) + \varepsilon_t \tag{4}$$

$$d(ra_t)=\alpha_t+ \beta\, d(wr_t) + \varepsilon_t \tag{5}$$

$$d(ra_t)=\alpha_t+ \beta\, ln(rer_t/rer_{t-1}) + \varepsilon_t \tag{6}$$

$$d(ra_t)= \alpha_t+ \beta\, ln(ner_t/ner_{t-1}) + \varepsilon_t \tag{7}$$

where:

- cpi_t stands for inflation,
- wr_t stands for the world interest rate calculated as the average of US, UK, Japan and Germany long-term interest rates weighted for their relative 1990 GDP values, and
- ner_t and rer_t stand respectively for the nominal and real effective exchange rate.

Differently from the independent variables of specifications (1), (2), (3), the above variables do not directly detect hedging as their variations do not necessarily correspond to a primary budget deterioration.

To clarify, consider specification (4). Inflation can arise from either a negative supply shock (oil shock) or a positive demand shock (rise in consumption levels), only the first though leading to a budget deterioration. Thus, a negative β can be interpreted as a sign of hedging only when the correlation of inflation with output is negative and with public spending is positive.

Inflation and world interest rate appear to be very significant at affecting debt servicing costs, while exchange rate regressors much less.

As to corroborate this analysis, multivariate regressions were also run as to test the explanatory power of the variables when combined together. Provided that

[32] The coefficient is deemed significant when the P-value of the *t*-stat is below 0.01.

debt costs' fluctuations critically hinge on the debt structure put in place by each country, it was not appropriate to test a single specification,[33] but all the following:

$$d(ra_t) = \alpha_t + \beta\,(x_1) + \gamma\,(x_2) \tag{8}$$

$$d(ra_t) = \alpha_t + \beta\,(x_1) + \gamma\,(x_2) + \lambda\,(x_3) \tag{9}$$

$$d(ra_t) = \alpha_t + \beta\,(x_1) + \gamma\,(x_2) + \lambda\,(x_3) + \zeta\,(x_4) \tag{10}$$

$$d(ra_t) = \alpha_t + \beta\,(x_1) + \gamma\,(x_2) + \lambda\,(x_3) + \zeta\,(x_4) + \varpi(x_5) \tag{11}$$

$$d(ra_t) = \alpha_t + \beta\,(x_1) + \gamma\,(x_2) + \lambda\,(x_3) + \zeta\,(x_4) + \varpi(x_5) + \delta(x_6) + \varepsilon_t \tag{12}$$

where x_1, x_2, x_3, x_4, x_5, x_6 are all the possible combinations taken from the following set of independent variables:

$$\left(\begin{array}{l} ln(GDP_t/GDP_{t-1}) \\ d(ur_t) \\ d(sp_t) \\ d(cpi_t) \\ d(wr_t) \\ ln(rer_t/rer_{t-1});\ ln(ner_t/ner_{t-1})^{34} \end{array}\right)$$

This implied a total of 1,520 regressions. Such approach was not chosen with the intent of searching for a "true" model. Indeed, as mentioned earlier, the truth of the model is a dynamic concept, as it depends on the country's debt structure and not on the legitimacy of the regressors. The objective was, then, to investigate in depth the significance of the variables and to what extent they affect debt servicing costs. This was done in two steps:

1) All non-significant regressions, *i.e.* those having a P-value of the F-test above the 10 per cent threshold, were removed.
2) The remaining 1,063 regressions where then grouped by variable. The group of *cpi*, for example, consists of all the regressions from (8) to (12) where $d(cpi_t)$ is found significant, *i.e.* where its P-value is below 10 per cent.

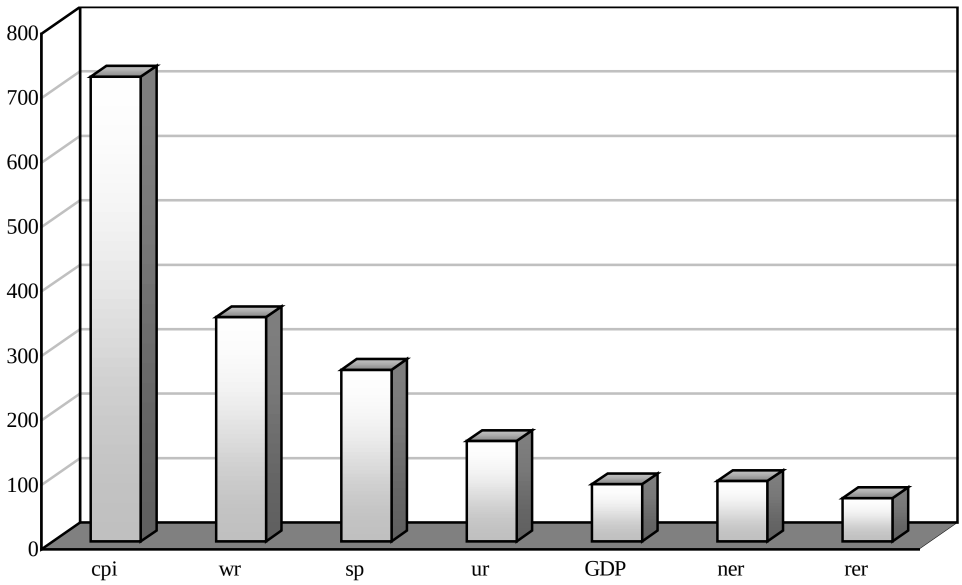
In Figure 4 we present the robustness of each variable, measured by the number of regressions for each group.

[33] Sala-i-Martin (1998), in his attempt to explain growth, run all possible combinations of a large set of variables. Such procedure represents a solution in case the exact specification is unknown. Indeed, in multivariate regressions one can often find variable x_1 to be significant only when paired with x_2 or x_3, but not with x_4.

[34] Nominal and real exchange rate do not enter together in the regression as they are considered substitutes.

Figure 4

Robustness Analysis



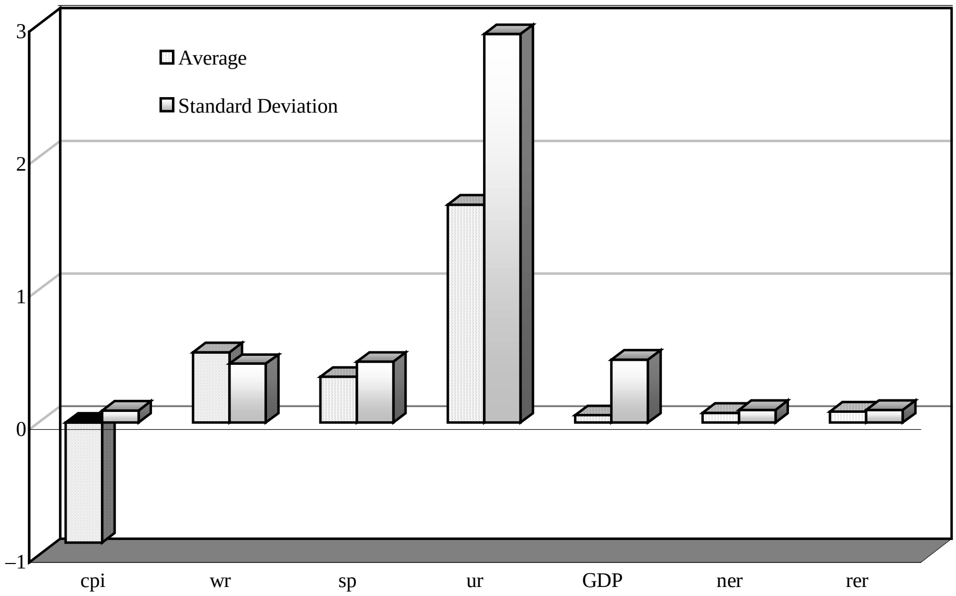
Results show that movements in debt costs are mainly explained by inflation and world interest rate. The implicit state contingent variables such as spending, unemployment rate and GDP (*i.e.* whose coefficients directly detect hedging) are much less significant pointing to their marginal influence at affecting debt costs. *ner* and *rer* also show not to be so robust due to the marginal role played by foreign currency denominated debt across nations.

The direction and extent of the effects on interest payments is presented by analysing the average and standard deviation of each coefficient. As Figure 5 shows, inflation, and to some extent world interest rate, are the only variables that present a definite behaviour. The high standard deviations of the other variables, instead, point to a rather heterogeneous scenario, signalling substantial differences across countries.

Results at a country level are, instead, presented in Tables 2 and 3. With regard to the variables potentially detecting hedging, *i.e., GDP*, *ur* and *sp*, results somehow confirmed those of simple regressions (it is for this reason that we prefer not to present simple regressions' results). Italy, Spain, Finland Austria, Spain, Norway, the Netherlands, the United Kingdom, Germany and Portugal exhibited countercyclical behaviour of debt servicing costs. Contradictory results are those of Canada, United States, Japan, France, Ireland and Sweden: indeed some coefficients point to hedging and some others not.

Figure 5

Average and Standard Deviation of the Variables



With regards to *inflation*, regressions are all very significant and presenting a negative coefficient approximately equal to one for every country. This implies that every country reduced the value of its real liabilities in the same proportion as the inflation experienced, meaning that the latter was almost always unexpected.

With regards to the *world interest rate***,** all countries except Spain exhibit a positive coefficient. The influence of this variable on debt servicing costs is overall substantial: coefficients indeed vary from a minimum of 0.20 for Germany to a maximum of 1.27 for Japan.[35] The variability of those results derive from the kind of debt structure implemented. Countries with a long debt maturity, being less exposed to interest rate innovations, should exhibit low β's. The high degree of financial interdependence, clearly stemming from the results, calls then for an issuance strategy that looks carefully at the policies of the leading economies' central banks, as all countries, although to different extent, import the consequences of such actions.

Regarding the *exchange rate* regressions, it seems that both nominal and real exchange rate are almost irrelevant at affecting debt costs. Coefficients for both *rer*

[35] Given that on average the share of long-term debt in Japan is high, such a high coefficient is counterintuitive. The explanation resides on the fact that in the first half of the Seventies the maturity was much shorter and debt servicing costs recorded higher swings compared to the world interest rate. Indeed, by taking out those outliers, the simple regression coefficient jumps from a coefficient of 1.6 to 0.8.

and *ner* are, compared to the other regressors' coefficient, very close to zero. With regard to the nominal exchange rate the sample is split in two. The UK, Portugal, Italy, France and Finland seem to have somewhat benefited from appreciations. However, such outcome can be attributed to the presence of foreign currency denominated debt just for Finland. In the last thirty years, those securities accounted on average for 49 per cent of Finnish public debt. As for the others, given the marginal or null presence of foreign currency denominated debt, the negative coefficient can be ascribed to the price effects accompanying the swings in the exchange rate. Indeed, regardless of the causality order, if PPP holds, deflation should correspond to nominal appreciations. If so, when a high share of deflatable securities (*i.e.* securities whose real value is negatively affected by inflation) is in place, real interest rates will increase substantially. This seems, indeed, to be the case as all those countries exhibit the highest shares of short-term and variable rate debt of the sample. Conversely, countries with high shares of long-term debt exhibit a positive coefficient. Moreover, results highlight that even when the share of foreign currency debt is substantial, as in Austria and Sweden, the impact on debt interest payments is small because outperformed by that exerted by other debt instruments. In Goldfajn (1998), the optimal share of foreign currency debt depends on the covariance between nominal exchange rate and inflation. Foreign currency debt can play as a substitute for long-term debt in case PPP does not hold, *i.e.* when Cov(*ner*, *cpi*)>0. Vice versa, foreign currency may be used as to limit the risk exposure when nominal debt is in place. Indeed, when unexpected deflation occurs, the loss determined by long-term nominal debt is balanced out by foreign currency debt via nominal appreciation. The same, of course, applies for price indexed debt. However, beyond the covariance of exchange rate with output and spending, one should also look at the exchange rate variance as to evaluate the optimal share of foreign currency denominated debt. In Missale (1999) *rer* variance was found much higher than that of inflation, suggesting price-indexed debt as a better form of hedging compared to foreign currency denominated debt.

Conclusions

In absence of explicit state-contingent debt, an optimal hedging portfolio should be chosen on the basis of the covariances between variables affecting real interest rates, *i.e.* inflation and real exchange rate, and variables affecting government financing needs, *i.e.* output, spending and unemployment. One point of departure to minimise budgetary risk could be that of exploiting historical covariances. However, nothing ensures that those covariances will last in the future. Covariances, indeed, change according to the nature of the macroeconomic shock occurring and both the central bank and government reaction to that. Thus, particular attention should thus be devoted to the interrelation between monetary policy and fiscal policy with debt management. In other words, depending on the specific characteristics of the economy and the monetary regime in place, say whether the central Bank targets inflation or nominal exchange rate, different covariances should be expected between inflation and the variables affecting public budget. More research is then needed in case debt managers were given the mandate of targeting macroeconomic risk in their strategy.

One should, anyway, bear in mind that such objective should never be pursued when in conflict with cost minimisation. Indeed, the approach should be that of moving towards the optimal risk-hedging portfolio until a trade-off between cost and risk emerges. A trade-off may even not arise at all: indeed, if negative shocks are mainly demand driven, one expects to have recessions coupled with deflationary phenomena. In this case, the use of price-indexed debt allows debt managers to minimise both cost (via a positive inflation premium) and risk.

With such a background, security diversification is crucial as allows debt managers to be better equipped to face the challenges of an ever changing world. It is also for those reasons that the Italian Treasury decided to enter the inflation-linked bond market.

Table 2

Multivariate Significant Regressions Grouped by Country*

	AUT			BEL			CAN			ESP			FIN			FRA			GER			IRE		
Var	No	Avg	Dev.	No	Avg	Dev.	No	Avg	Dev.	No	Avg	Dev.	No	Avg	Dev.	No	Avg	Dev.	No	Avg	Dev.	No	Avg	Dev.
GDP							**7**	**0.487**	**0.24**	11	–0.41	0.13	15	–0.31	0.12	**10**	**0.297**	**0.05**	4	–0.1	0.00			
sp	41	0.318	0.12	5	0.171	0.02				28	0.76	0.21	20	0.301	0.09	18	0.438	0.14	24	0.169	0.01	9	0.172	0.02
ur	24	1.288	0.58				6	0.631	0.35	15	0.43	0.17	5	0.579	0.11	3	0.939	0.02	2	0.421	0.00	**7**	**–0.24**	**0.07**
cpi	48	–0.89	0.03	48	–0.87	0.02	48	–0.81	0.04	48	–0.9	0.05	48	–0.94	0.04	48	–0.96	0.07	48	–0.74	0.03	48	–0.96	0.03
wr	28	0.316	0.10	24	0.565	0.04	28	0.412	0.25	19	–0.31	0.07	6	0.484	0.08	48	0.492	0.21	17	0.208	0.01	33	0.545	0.28
ner	4	0.15	0.09	9	0.19	0.02							2	–0.12	0.01	4	–0.06	0.00	27	0.09	0.04			
rer	2	0.07	0.00	9	0.20	0.02				1	0.11								8	0.08	0.00			

* Column "Var" represents the independent variable on which the filtering has been made and thus the group. "No" stands for the number of the group's regressions, while "Avg" and "Dev." stand respectively for the average and standard deviation of the independent variable.
- Boxes are empty when no significant coefficient was recorded.
- Coefficients are in bold when pointing to hedging.

Table 3

Multivariate Significant Regressions Grouped by Country*

	ITA			**JAP**			**NET**			**NOR**			**PRT**			**SWE**			**UK**			**US**		
	No	Avg	Dev.	No	Avg	Dev.	No	Avg	Dev.	No	Avg	Dev.	No	Avg	Dev.	No	Avg	Dev.	No	Avg	Dev.	No	Avg	Dev.
GDP	8	–0.61	0.15	**18**	**0.477**	**0.36**										**3**	**0.69**	**0.04**				**12**	**0.202**	**0.40**
sp	40	0.664	0.40	25	0.328	0.21	15	0.133	0.01				19	0.745	0.23							**21**	**–0.67**	**0.69**
ur	12	1.493	0.19	23	6.513	5.29	29	0.233	0.08	1	1.19					3	1.42	0.05	1	0.993		24	1.15	0.94
cpi	48	–0.88	0.08	48	–1	0.02	48	–0.87	0.02	48	–0.98	0.02	48	–1.06	0.01	47	–0.84	0.01	1	–0.92		48	–0.89	0.07
wr	48	0.701	0.38	30	1.268	0.60	6	0.236	0.01							11	0.484	0.05	1	1.129		48	0.591	0.42
ner	4	–0.06	0.01				8	0.12	0.01				8	–0.11	0.01	4	0.13	0.00				23	0.09	0.05
rer							10	0.12	0.01				1	–0.48		7	0.05	0.00	1	–0.18		27	0.07	0.04

* Column "Var" represents the independent variable on which the filtering has been made and thus the group. "No" stands for the number of the group's regressions, while "Avg" and "Dev." stand respectively for the average and standard deviation of the independent variable.
- Boxes are empty when no significant coefficient was recorded.
- Coefficients are in bold when pointing to hedging.

Table 4

Breakdown of Central Government Public Debt*

	Non-Deflatable Securities (Short-term + Variable rate + Price Indexed Debt)			Medium-term Debt (2-5 yrs)			Long-term Debt (>5 yrs)			Long + Medium			Foreign Currency Denominated Debt		
	Avg	Dev	Yrs	Avg	Dev	Yrs	Avg	Dev	Yrs	Avg	Dev	Yrs	Avg	Dev	Yrs
AUT	9%	3%	22			0	51%		30	51%		30	16%	3%	22
BEL	14%	10%	23	26%	7%	23	32%	7%	23	58%	13%	23	4%	2%	20
CAN	64%	5%	21	9%	2%	21	26%	3%	21	35%	5%	21	3%	2%	21
GER	9%	3%	22	26%	7%	22	40%	14%	22	67%	20%	22	-	-	-
ESP	33%	18%	22	21%	9%	21	19%	17%	21	41%	25%	21	3%	1%	13
FIN	26%	7%	12	33%	4%	12	32%	6%	12	65%	9%	12	37%	16%	12
NOR	24%	6%	20	23%	6%	20	26%	6%	20	49%	6%	20	12%	10%	20
FRA	59%	24%	26	23%	1%	10	52%	3%	10	75%	4%	10	5%	1%	7
UK	59%	5%	12	22%	6%	12	13%	3%	12	35%	5%	12	-	-	-
IRE	17%	10%	7	17%		1	29%		1	46%		1	19%	13%	7
ITL	57%	13%	22	17%	5%	17	14%	10%	17	31%	15%	17	4%	2%	20
JPN	17%	3%	22	25%	4%	22	39%	5%	22	64%	6%	22	0%	0%	7
NET	8%	5%	20	34%	6%	9	50%	11%	22	63%	17%	22	-	-	-
PRT	48%	30%	25	12%	7%	14	21%	18%	9	26%	23%	14	6%	1%	2
SWE	31%	4%	22	64%	7%	22			0	64%	7%	22	21%	6%	22
USA	41%	5%	22	30%	3%	22	23%	2%	22	53%	4%	22	1%	0%	2

* Source: All data are elaborations from the 2003 Central Government Debt statistical yearbook – OECD except some figures of Portugal, France and Austria that were kindly provided by Missale.

REFERENCES

Alesina, A. (1992), "Default Risk on Government Debt in OECD Countries", *Economic Policy: A European Forum*, Cambridge University Press.

Avellaneda, M. and P. Laurence (2000), "The Heath-Jarrow-Morton Theorem and Multidimensional Term-Structure Models", in *Quantitative Modelling of Derivative Securities*, Chapman & Hall, Chapter 13.

Barone, E. (1996), "Gestione del debito pubblico e tassi d'interesse", *Rivista AIAF*, No. 18.

Barro, J.R. (1979), "On the Determination of the Public Debt", *Journal of Political Economy*, Vol. 87, pp. 940-71.

Bartunek, K. and C. Mustafa (1994), "Implied Volatility v. GARCH: A Comparison of Forecasts", *Managerial Finance*.

Bohn, H. (1988), "Why Do We Have Nominal Government Debt?", *Journal of Monetary Economics*, Vol. 21, pp. 127-40.

——— (1990), "Tax Smoothing with Financial Instruments", *American Economic Review*, December, pp. 1217-30.

Bolder, D.J. (2003), "A Stochastic Simulation Framework for the Government of Canada's Debt Strategy", Bank of Canada, Working Paper, No. 2003-10.

Bulchandani, R. (1996), "Spread Economics: Interest Rates after EMU", in *International Investment Research*, Morgan Stanley.

Campbell, J. (1995), "Some Lessons from the Yield Curve", *Journal of Economic Perspectives*, Vol. 9, pp. 129-52.

Congressional Budget Office (1993), *Federal Debt and Interest Cost*, Washington (D.C.), U.S. Government Printing Office.

Dantzig, G.B. (1963), *Linear Programming and Extensions*, Princeton (N.J.)., Princeton University Press.

Dornbusch, R.W. and M. Draghi (1990), *Public Debt Management: Theory and History*, Cambridge University Press.

Favero, C., F. Giavazzi and L. Spaventa (1995), "High Yields: The Spread on German Interest Rate", mimeo.

Favero, C., A. Missale and G. Piga (2000), "EMU and Public Debt Management: One Money, One Debt?", CEPR, Policy Paper, No. 3.

Giavazzi, F. and M. Pagano (1989), "Confidence Crises and Public Debt Management", NBER, Working Paper, No. 2926.

Giovannini, A. (1995), "Borrowing in International Capital Markets: Lessons from Experience", mimeo.

Heath, D., R. Jarrow and A. Morton (1992), "Bond Pricing and the Term Structure of Interest Rates: A New Methodology", *Econometrica*, Vol. 60, No. 1, pp. 77-105.

Jackson, D. (2000), *The New National Accounts: An Introduction to the System of National Accounts 1993 and the European System of Accounts 1995*, Camberley (UK), Edward Elgar.

James, J. and N. Webber (2000), *Interest Rate Modelling*, John Wiley & Sons.

Lamourex, C.B. and W.D. Lastrapes (1993), "Forecasting Stock Return Variance: Toward an Understanding of Stochastic-Implied Volatilities", *Review of Financial Studies*, Vol. 6, No. 2, pp. 293-326.

Maciejowski, J.M. (2002), *Predictive Control with Constraints*, London, Prentice Hall.

Maggi, B., S. Ginebri and M. Turco (2005), "The Automatic Reaction of the Italian Government Budget to Fundamentals: An Econometric Analysis", *Applied Economics,* Vol. 37, No. 1, pp. 67-81.

Missale, A. and O. Blanchard (1994), "The Debt Burden and Debt Maturity", *American Economic Review*, Vol. 84, No. 1, pp. 309-19.

Missale, A. (1997a), "Managing the Public Debt: The Optimal Taxation Approach", *Journal of Economic Surveys*, Vol. 121, No. 3.

―――――― (1997b), "Tax Smoothing with Price-indexed Bonds: A Case Study of Italy and the United Kingdom", in M. De Cecco, L. Pecchi and G. Piga (eds.), *Managing Public Debt*, Edward Elgar.

―――――― (1998), "Optimal Debt Management with a Stability and Growth Pact", IGIER, Working Paper, No. 166.

―――――― (2000), *Public Debt Management*, Oxford, Oxford University Press.

―――――― (2001a) "Optimal Debt Management with a Stability and Growth Pact", *Public Finance and Management*, Vol. 1, No. 1, pp. 58-91.

―――――― (2001b), "Public Debt Management and the Stability and Growth Pact", in A. Brunila, M. Buti and D. Franco (eds.), *The Stability and Growth Pact – The Architecture of Fiscal Policy in EMU*, pp. 344-68, New York, Palgrave.

Modigliani, F., M. Baldassarri and F. Castiglionesi (1996), *Il miracolo possibile*, Laterza.

Morgan Guaranty Trust Company – Reuters, *RiskMetrics – Technical Document*, Third Edition.

Pecchi, L. and S. Scalera (1997), "La gestione del debito verso Maastricht per i paesi High Yielders", *Rivista Italiana degli Economisti*, No. 1/97.

Torosantucci, L. and A. Uboldi (2002), "Empirical Analysis of the Italian Treasury Fixed-income Securities Market with the CIR Model", Quaderno IAC, No. Q27-002.

Turco, M. (2001), "Are Debt Structures Hedging? Evidence from an OECD Sample", mimeo.

Yong, J. and X.Y. Zhou (1999), *Stochastic Controls*, Springer Verlag, New York.