Economic Growth and Public Debt: An Experimental Approach in Search of a Confidence Channel

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Economic Growth and Public Debt: An Experimental Approach in Search of a Confidence Channel

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Abstract

This paper aims at investigating the relationship between public debt and the consumption side of economic growth from an experimental macroeconomics point of view, by analysing whether consumers’ expectations about public debt are linked to tax compliance, consumption, and savings choices, that in turn affect GDP.

To this end, we have implemented a laboratory experiment in which the participants earn an income to be allocated between consumption, savings, and voluntary taxation for an unknown number of rounds. Debt’s dynamics arises endogenously within a public good game with threshold: taxation is used to cover a given level of public expenditure, which is equally distributed to the participants at the beginning of each subsequent round. If the collected amount of taxes is lower than required, a deficit is generated, and it feeds public debt. Debt can then be unexpectedly reduced by the government through accessing subjects’ savings. To check for the role of beliefs, participants’ expectations about future debt reduction and perceived debt sustainability are elicited during the experiment.

Results show that this experimental framework is characterized by relatively high and often increasing aggregate savings and relatively low and decreasing aggregate consumption. An increase in the debt-reduction expectations and a decrease in the perceived debt sustainability are also found to explain savings and consumption behaviours. These conclusions do not change if tax audits are introduced, but the average savings level lowers, thus increasing subjects’ exposure to the unexpected shocks.

Keywords: experimental macroeconomics, public debt, economic growth, expectations, intertemporal choices, public-good games, fiscal audits.
1. Introduction

The idea that public debt is always harmful to economic growth has partially been reconsidered in the last few years. Some works have shown that a general debt-threshold above which growth is stifled is unlikely to exist (see, among others, Pescatori et al., 2014; Woo and Kumar, 2015). Nevertheless, the existence of a linkage between debt and growth has not been rejected: the long-run relationship between such macroeconomic variables is inevitably and broadly affected by heterogeneous economic and behavioural factors. The focus of this paper is on the latter and, in particular, on the behaviour of those consumers that faces the uncertainty of having to bear the cost of a public debt reduction, a situation that has barely been studied from an empirical perspective due to a lack of data. In fact, though some works have studied the impact of fiscal policies on the aggregate demand through model simulations and event studies (a review is provided in Briotti, 2005), to the best of our knowledge the role that debt-related expectations play in uncertain fiscal conditions has not yet been developed.

This was the case of those peripheral countries of the Eurozone that were involved in the debt crisis between 2011 and 2012\(^1\), and by the austerity measures implemented in the aftermath that deeply affected the whole economic system. In fact, uncertainty about future fiscal policies and about the future sustainability of public debts might have amplified the contractionary impact that these measures had on growth rates. In the same period, the idea of a forced withdrawal from current accounts was retaken in some countries: notably, Italy faced this possibility in 2011 (as reported by many Italian newspapers), after the remarkable experience of 1992. Between July 9 and July 10, 1992, Amato’s government actualized an unexpected 6% forced withdrawal on all bank accounts in order to respond to the imminent financial crisis and to the speculative attacks that led

\(^1\) Spain, Italy, Portugal, Greece, and Ireland were involved in speculative attacks that had the potential to be self-fulfilling; see De Grauwe and Ji, 2013.)
Italy out of the European Monetary System (EMS). In such situations, uncertainty about future fiscal policies and political actions might have influenced consumers’ expectations, thus affecting the general economic performance.

To gain insight into the role of expectations about debt policies and their impact on economic growth under uncertainty conditions, we have studied how people react in a framework in which public debt may be unexpectedly reduced by implementing a laboratory experiment in which the debt dynamics arises endogenously: within a public good game, taxes are collected from all participants and are used to cover a given level of public expenditure, which is then equally distributed to the same participants at the beginning of each experimental round. If the collected amount of taxes is lower than what the public expenditure would require, a public deficit is generated. Moreover, reproducing a forced withdrawal, the outstanding amount of public debt can be reduced upon accessing subjects’ savings.

Within this setting, expectations are elicited directly by asking subjects if they believe that public debt is going to be reduced, and if they think that the other subjects believe that public debt is sustainable. Therefore, we can identify whether and how agents’ allocations and expectations are affected by the public debt path. The main goal is to study whether and when direct and indirect consumers’ beliefs about public debt affect their choices about consumption, savings, and tax compliance\(^2\) with a direct impact, at the aggregate level, on economic growth, interpreted as the GDP growth rate.

As mentioned above, a peculiarity of this approach is the endogenous dynamics of public debt: not only it avoids introducing predetermined dynamics, but also increases the ecological validity of the experiment. Participants are indeed more psychologically involved in the debt mechanism and they might feel responsible for the raise in debt, as they might feel when, for instance, the party for which they voted increases deficit.

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\(^2\) To keep the framework as simple as possible, we did not considered investments.
spending. On the other hand, an exogenous dynamics might depict public debt and tax compliance as irrelevant.

The rest of the paper is organized as follows. First, in Section 2 we review the literature involving public debt and economic growth with particular attention to expectations. This section is useful to provide a theoretical background for the following experimental hypotheses. In Section 3 we introduce the experimental literature, our research questions, our experimental design and the strategic analysis. The experimental data are discussed in Section 4, and general implications are inferred through panel models and robustness analysis. Section 5 concludes.

Findings clearly support the existence of a confidence channel, namely a linkage between debt and growth based on and determined by expectations: a worsening in the perceived debt sustainability is associated with an increase in aggregate savings and a decrease in aggregate consumption, regardless the level of the public debt.

### 1.1. Expectations within standard economic theories

Implications about consumers’ behaviour are to be found within the existing economic approaches, each of which provides different implications. In the standard Neoclassical theory, the focus is on the crowding-out effect entailed by public deficits. On the consumption side and under the assumption of perfectly rational agents, with a finite lifespan and with access to perfect markets, the government borrowing allows to increase the predetermined consumption level of the current generation, as taxes are indefinitely postponed to next generations. Nevertheless, given fully employed resources, the raise in consumption must go hand in hand with a decline in savings, thus implying, on the investment side, an increase in the interest rate towards the new equilibrium, with the result that private capitals are crowded-out\(^3\) (see Bernheim, 1989). Therefore, the typical impact of an increasing public debt on the long-run economic growth can be assumed to be

\(^3\) All these aspects are included in the seminal model proposed by Diamond (1965).
negative, because of the crowding-out effect and because of the taxes required to finance
the future interest payments, a point on which is hinged the so-called burden view
(Modigliani, 1961).

This conclusion has also found support within the endogenous growth approach (for
instance, Barro 1990, and Saint-Paul 1992), according to which the growth rate may be
jeopardised by the direct and indirect influence of fiscal policies and outstanding debt.
Noteworthy, as shown by recent studies, the negative consequences may be larger if
government debt creates uncertainty, and if it generates expectations of future higher
taxes (Cochrane, 2011), or if it affects the productivity of public expenditure (Teles and
Cesar-Mussolini, 2014). Upon including different elements of analysis, some Neoclassical
developments have allowed for broader results that show that public deficits may have a
positive impact on growth. Nonetheless, since people are perfectly rational, they react to
permanent income changes only, directly or indirectly determined by variations in the
taxation level and in the public expenditure, though the final consequence may not be
unfavourable.

The Keynesian theory, instead, assumes that a deficit financed fiscal expansion can have
an expansionary impact on the aggregate demand. Indeed, if the resources are not fully
employed, national income rises, generating the Keynesian multiplier effect that
stimulates both the national income and the consumption level (Hemming et al., 2002),
whereas, at the same time, taxes entail a short-run contractionary effect. However, as
noted by some authors, expectations about the contractionary fiscal policies may outweigh
the negative Keynesian multiplier effect leading to an expansion rather than a contraction
(Barry and Devereux, 1995). Moreover, if indirect changes in the interest rate affect the
magnitude of the multiplier, as described by Hemming et al. (2002), the Neoclassical
crowding-out effect could still arise.
Last but not least, the Ricardian paradigm is based on the idea that agents incorporate the government intertemporal budget constraint, thus implying the irrelevance of the timing of taxes and, indirectly, the equivalence between taxes and government debt in financing the public expenditure. Besides, the change in the taxation level does affect the savings level, which follows the expected variation in the future disposable income. In this context, unlike the other approaches, a public deficit entails a full crowding-out effect. In Barro (1989) the author concluded that the Ricardian Equivalence is a "good first-order approximation to reality", supported also by the empirical evidence, but this conclusion has been criticized by some authors. For instance, in Bernheim (1989), the Ricardian paradigm is deemed to require unrealistic assumptions to hold.

1.2. Further theories

An unconventional approach named "expansionary fiscal consolidation theory" has initially been discussed in the 90s by a group of Italian economists, who have proposed that a deficit reduction policy might have an expansionary effect on the economic system. In other words, a policy of deficit reduction could be associated with an expansion in the aggregate demand. This view was mainly introduced and discussed by Giavazzi and Pagano (1990), and Alesina and Perotti, (1995), and then retaken and revisited amid the European public debt crisis by Alesina and Ardagna (2010) and Alesina and Ardagna (2013) among others. However, the importance of this controversial school of thought has undeniably faded away, especially after the publication of some works that have casted doubts on its empirical relevance. For instance, the work of Perotti (2012) has showed that the explanations of four episodes of expansionary fiscal consolidations were to be found in exceptional and particularly favourable conditions in which they were implemented and not in the implemented policies. Yet, a similar expansionary effect may rather arise because of expectations: if people expect a future fiscal consolidation, they will save more
until when the consolidation effectively occurs; as soon as such a consolidation has occurred, people increases their consumption (Sutherland, 1997).

1.3. Expectations and fiscal policies in experimental economics

Laboratory experiments are an extremely useful tool for the investigation of economic and fiscal policies since they allow the construction of a simplified and controlled framework in which to test for their validity, above all when empirical data are not available. In fact, though macroeconomic policies have been traditionally studied through non-experimental techniques, in the last few years experimental macroeconomics has gained wider academic interest.\(^4\)

In the specific field of fiscal policies and expectations, the first experimental designs aimed at testing the Ricardian Equivalence within an overlapping generations framework. Cadsby and Frank (1991) have supported the empirical validity of the Ricardian Equivalence, but subsequent developments have found evidence of departures when more articulated experimental designs are employed (Slate et al., 1995; Ricciuti and Di Laurea, 2003).

A group of studies have focused on expectation formation and dates back to the 70s. For instance, Bernasconi et al. (2009) has studied the ability of people to forecast, either in front of real-world data or laboratory data. Other experimental designs have studied expectation formation with respect to inflation (Arifovic and Sargent, 2003) or with respect to monetary policies (Kryvtsov and Petersen, 2013; Pfajfar and Zakelj, 2015; Assenza et al., 2014). However, these experiments do not explicitly deal with public debt, the debt-to-GDP ratio, and its effect on consumption and savings. As regards, only Geiger et al. (2016) have explicitly analysed fiscal consolidations, finding that an expectations channel linking fiscal policies and consumption exists, thus supporting the expansionary effect of Sutherland (1997): "Consolidations that occur in an unsustainable fiscal environment

\(^4\) For a detailed review of experimental macroeconomics, see Duffy, 2014.
exert less contractionary effects on consumption, [...] and this channel is more pronounced if the fiscal authority can convincingly commit to abstain from tax increases in the future (Geiger et al., 2016, p.15)."

Our design undoubtedly shares some similarities with Geiger et al. (2016), but it differs in some important points that we will present in the next sections: the earning money task (in contrast with the house money approach of Geiger et al., 2016), the direct elicitation of the perceived debt sustainability and debt forecasts, and the endogenous dynamics of the public debt, for which all the participants are responsible. Therefore, our design is more sophisticated and keeps a greater number of variables under control.

Similarities are shared also with the vast experimental literature about tax evasion\(^5\) and with the literature of the public good experiments with thresholds, in which subjects provide a freely determined amount to a public fund characterized by a given threshold. Within this setup, such a threshold represents the total amount of contributions (i.e. voluntary paid taxes) required to cover an exogenous level of public expenditure. Since a basic public good game does not commonly lead to full coordination between the subjects, it is already possible to say that the experimental debt dynamics will generally be upward trending, as observed in many developed countries during the last decades.

2. Research questions and behavioural hypotheses

The experimental design aims at identifying the possible confidence channel that links public debt and economic growth, and whether it has an impact on the savings level. According to the economic theories introduced above, people's expectations may be interpreted in a Ricardian sense, may follow the Neoclassical theory, or may be in line with Sutherland (1997) and Geiger et al. (2016). It would also be possible to observe no influence at all.

\(^5\) Tax payer behaviour is extensively studied from an experimental perspective. See Baldry (1987), Bosco and Mittone (1997), Mittone (2006).
Thus, the first research question aims at disclosing whether public debt expectations affect consumers' choices:

**RQ1. Is there a confidence channel linking public debt and the consumption side of economic growth?**

where the confidence channel is any expectational linkage, a broader concept than the expectations channel of Sutherland (1997) and Geiger et al. (2016). Indeed, our approach is "to let the experimental data speak", without imposing any restrictions on such a channel.

An expectational channel might arise or might not arise according to the individual perception of the fiscal policies, namely, according to the uncertainty about the future probability of a debt reduction carried out by the government. Moreover, it can play a role in specific situations only, such as when public debt is perceived to be unsustainable. The second research question deals precisely with this aspect:

**RQ2. Does the perceived debt sustainability affect the choices of the subjects?**

Since, as said above, people may react according to the perceived debt sustainability and to personal beliefs, three behavioural hypotheses can be made about the dynamics of the aggregate private consumption and savings level observed in the experiment:

- **Hypothesis 1.** Given a constant public expenditure level, participants react to increasing public debt — namely, consecutive deficits — by increasing their own consumption level. This result would be explained by the Neoclassical theory if subjects believe that required taxes are indefinitely postponed and no debt reduction will occur. However, this behaviour can also be in line with the Keynesian theory, which attributes a multiplier effect on the deficit financed public expenditure in contrast with the contractionary effect implied by taxation, or by a debt-reduction intervention. If, instead, such a debt-reduction intervention led to an increase in consumption, subjects would react according to the expansionary
fiscal consolidation hypothesis.

- Hypothesis 2. Participants react to increasing public debt by reducing, on average, their consumption and by increasing savings. Therefore, participants behave in a sort of Ricardian way: they expect that debt has to be repaid in the future, and they react by increasing the current savings levels. Moreover, uncertainty can amplify this result.

- Hypothesis 3. Given their income level, participants do not adjust their own consumption and savings levels to variations or expected variations in public debt. In this case, participants do not care about public debt if it does not affect their income permanently through, for instance, an explicit increase in the fiscal pressure.

Evidently, different behaviours can emerge if different time horizons are considered; therefore, more than one hypothesis can be satisfied.

A last research question strictly linked to the experimental design involves tax compliance. In particular, it is interesting to understand whether and how the answers to the previous research questions are affected by voluntary taxation, a fundamental aspect of the experimental design. Given the endowment of the subjects, an increase in the fiscal contribution, namely a reduction in tax evasion, might intuitively lead to either a lower level of consumption, a lower level of savings, or a lower level of both, with different economic implications. Therefore, as described in Section 3, we will introduce tax controls and the third research question deals with it:

*RQ3. Does an increase in fiscal contribution induced by a more severe fiscal strategy impact on consumption and/or savings?*

It must be underlined that the introduction of fines and fiscal audits mimics an increase in fiscal pressure without altering the general experimental framework.
3. Experimental design

The experimental design is based on the public good games with thresholds, with earned-money and voluntary taxation, and without interactions between subjects. It does not aim to test a specific macroeconomic model, but to find out whether and how people’s expectations about public debt affect their choices about consumption and savings in uncertain fiscal conditions, resembling, for instance, the situation in which many European countries were involved during the Sovereign Debt Crisis and the austerity period.

We develop two similar experimental designs whose difference is in the absence or presence of controls on tax evasion.

3.1. Design without tax controls

The experiment comprises of $t = 1, \ldots, T$ periods, where $T$ is a random number extracted from a discrete uniform distribution $U(10, 20)$: the minimum number of possible periods is $T = 10$ and the maximum is $T = 20$. Therefore, subjects do not know when the experiment ends, and any end-effect is avoided. Before period $t = 1$, subjects join in an earning task that determines the annuity per period. This earning-money strategy should reduce the house-money effect that can arise in public-good experiments and that can affect subjects’ preferences (see Clark, 2002). Consequently, from period $t = 1$ to period $t = T$, subjects receive the constant amount $a_t$ per period, and the final gross income of each subject $i$ is:

$$A_i = \sum_{t=1}^{T} a_t$$

Subjects must decide how to allocate $a_t$ between the available private and public choices. On the private side, subjects can choose in each period between an immediate consumption ($c_p$) that, as described below, contributes to the final pay-off according to a factor $\gamma$

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6 These technical choices is arbitrary; there are no reasons to choose another strategy to avoid the end-game effect.
(0 < γ < 1), and positive savings (s_n) that can be used for future consumption only. Savings provides a constant interest rate r. If the stock of savings accumulated up to time t is \( S_t \)
the amount received in round \( t + 1 \) is thus \( S_{t+1} = S_t (1 + r) = S_t R \).

On the public side, subjects know that the government has to collect a given amount of resources in order to cover the public expenditure, say \( E_t \). This amount will be multiplied by \( \mu > 1 \) (a public-expenditure multiplier, known to all participants) and then equally divided among the participants at the beginning of the subsequent round. Therefore, in \( t + 1 \) each subject will receive the amount \( \left( \frac{\mu E_t}{N} \right) \), where \( N \) is the number of participants.

Subjects are told the amount that they should contribute to reach the threshold \( E_t \), but they are free to decide how much to contribute effectively, an amount \( T_t \) that remains unknown to all the other participants. Subjects might also decide to contribute more than what is suggested, a circumstance that would capture the subjective aversion to debt creation and the fear of a debt reduction. The collected amount in each round is thus:

\[
F_t = \sum_{i=1}^{N} T_t
\]

If \( F_t \geq E_t \), the amount \( \mu F_t \) is distributed. Instead, if \( F_t < E_t \), a deficit \( d_t = (E_t - F_t) \) is generated and the amount \( \mu E_t = \mu (F_t + d_t) \) is distributed. To cope with the insufficient amount of collected resources, the government has to resort to an exogenous amount of public debt, on which interests accrue according to a constant rate \( i \). The dynamics of public debt is described by:

\[
D_{t+1} = \begin{cases} 
(1 + i)(D_t + d_t) & \text{if } d_t > 0 \\
(1 + i)D_t & \text{if } d_t \leq 0 
\end{cases}
\]

where \( d_t < 0 \) corresponds to the situation in which, on the whole, participants contribute more than what is required to cover the public expenditure.
At the beginning of period $t$ and before subjects’ choices, the government can decide to reduce the outstanding amount of debt and interests, $D_t = [(1+i)(D_{t-1}+d_{t-1})]$, to a lower amount $\alpha D_t$ (with $0 < \alpha < 1$) by forcedly accessing the subjects’ outstanding amount of capitalised savings, and this can occur from 0 to $T-1$ times. If subject’s savings is higher than the unknown demanded amount $\left(\frac{\alpha D}{N}\right)$, subject’s savings is reduced by this amount; otherwise, savings is reduced to 0 and the subject is forced to pay a penalty on his final pay-off (this can be interpreted as a forced fiscal withdrawal on the final individual earnings which avoids affecting the dynamics of the experimental variables). The government cannot declare default on its public debt.

Summarizing, in the case in which $d_t > 0$, the government budget constraint in each period $t > 1$ represents the balance between revenues (tax income) and expenditures (public expenditure), reached through a deficit:

\begin{equation}
F_t + d_t = E_t, \text{ with } d_t \geq 0
\end{equation}

while, during the experiment, the subject $i$’s budget constraint is given by:

\begin{equation}
a_u + \max\left\{\frac{\mu E_{t-1}}{N}, \frac{\mu E_{t-1}}{N}\right\} + \max\left\{\left[p(S_{i,t-1}R - \frac{\alpha D_t}{N}) + (1-p)S_{i,t-1}R\right],0\right\} = c_u + S_u + T_u
\end{equation}

with $\{c_u, S_u, T_u\} \geq 0$, and $p$ being the exogenous probability of bearing a reduction in public debt (more details are given in the next section).

The monetary pay-off of each subject at the end of the experiment is determined by the realized consumption levels $c_u$ if $c_u \geq h$ (while levels below $h$ are disregarded), and by the accumulated number of penalties $m \geq 0$ that determines an overall compounded reduction equals to $(1-k)^m$. Savings and public expenditure do not contribute to the final pay-off. In such a way, $h$ is to be considered as the consumption subsistence level.

\footnote{The first period is excluded, no debt reduction can occur.}
Finally, in order to study expectations, in each period participants are asked two questions. If the answer is right, the "winning" participant receives \( \bar{g} \) tokens at the end of the experiment, otherwise he receives 0 tokens. These tokens do not contribute to the endowment of the participants: they cannot be spent, and they are provided at the end of the experiment only. Given a general conversion factor from tokens to euro of \( f \), the final monetary pay-off of subject \( i \) accumulated from period \( t = 1 \) to period \( t = T \) is thus:

\[
P_t(c_{it}, g_{it}) = f (1 - k)^{it} \sum_{t=1}^{T} (x_{it} + g_{it})
\]

where \( g_{it} = (0, \bar{g}) \) is the forecast-related earning amounts, and

\[
x_{it} = \begin{cases} 
rc_{it} & \text{if } c_{it} \geq h \\
0 & \text{if } c_{it} < h 
\end{cases}
\]

is the discounted total amount of the realized consumption.

### 3.2. Forecasts and final questionnaire

In each round subjects’ expectations are elicited. Two questions are asked after the allocation of the endowment and for which subjects receive a prompt response on their accuracy:

- **Forecast 1**: Do you believe that public debt will be reduced by the government in the next round?

- **Forecast 2**: How many participants do you believe that think that the actual level of public debt is sustainable?

For the first question, subjects enter "1" if they believe that public debt will be reduced and "0" otherwise. For the second question, subjects enter a number from 0 to the number of participants according to their perceived degree of debt sustainability, whose intuitive

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\( ^8 \) This methodology is commonly adopted in experimental economics to elicit expectations. For a review of experiments on expectations, see Assenza et al. (2014) and Duffy (2014). For applications, see Kryvtsov and Petersen (2013), and Duffy and Fisher (2005). Participants are trained through a training round.
definition was provided in the instructions (see the Appendix at the end of the paper). For each correct\(^9\) prediction, subjects receive a prize at the end of the experiment.

Therefore, subjects are simultaneously asked to provide their expectations about a future debt reduction (a short-term forecast) carried out by the government and the related perception of the current debt sustainability (a long-term forecast), which reflect the ability of the current and future government revenues to cover the current level of public debt. These questions aim to directly elicit subjects’ expectations, and to relate them to the current and past levels of consumption and public debt.

<table>
<thead>
<tr>
<th>Question</th>
<th>Possible answers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. In which slot does the actual (2017) Italian debt-to-GDP ratio fall?</td>
<td>60-100%, 100-120%, 120-140%, &gt;140%</td>
</tr>
<tr>
<td>2. In your opinion, will the debt-to-GDP ratio go up or down during the next 5 years?</td>
<td>Up, Down</td>
</tr>
<tr>
<td>3. Do you believe that the current level of the Italian public debt is sustainable?</td>
<td>Yes, No</td>
</tr>
<tr>
<td>4. Do you believe that the level of public debt directly or indirectly affects private consumptions?</td>
<td>Yes, No, I do not know</td>
</tr>
</tbody>
</table>

The analysis is then reinforced and linked to real world by a series of questions reported in Table 1 to be asked through a questionnaire at the end of the experiment which allows to get insight into the subjects’ general knowledge of the topic.

### 3.3. Laboratory implementation, calibration, subject pool

The structure of the laboratory experiment can be divided into four parts, as depicted in Figure 1.

In the first part, subjects join an earning task in which they have to correctly count the number of "1"s included in random tables for six times without time limits. This part is only meant to avoid the house-money effect and is carried out at the beginning of the experiment. Then, each subject receives the same number of tokens per round.

---

\(^9\) The tokens earned from forecasta are determined according to a beauty-contest game: the winner is the subject that provides the closest answer to the group average (it is possible to have more than one winner simultaneously). Subjects are not aware of such a mechanism but, since they are not competing against each other, this is not relevant for the experimental results.
In the second part, subjects must decide how to allocate their endowment between consumptions, savings, and voluntary taxation.

In the third part, the public debt level is updated, and subjects must provide their two forecasts by observing the available data (the public debt level, the debt-to-GDP ratio, the total amount of collected taxes, and the related public deficit). At the beginning of the subsequent round, subjects discover whether public debt is reduced or not and whether their forecasts are correct. Then, part two and three are repeated for each round until the end of the experiment.

The fourth and last part at the end of the experiment includes the Holt and Laury (2002) task to measure risk aversion.

The values of the many parameters are calibrated for 18 and 20 participants to each laboratory session, and they are reported in Table 2. The number of rounds \( T \) is fixed to 15, unknown to the participants in order to avoid an end-effect; as described above, they only know that the experiment will finish between period 10 and 20 (the fixed number of rounds made the comparison of data easier). Tokens are the unit of measure of the whole laboratory experiment: in each round the endowment is composed by an income \( a_n = 10 \) tokens and a public transfer of 9 tokens, given by the public expenditure amount multiplied by \( \mu = 1.2 \) (arbitrarily chosen) and divided by the number of subjects. The minimum consumption level required to avoid penalties is \( h = 6 \) tokens, while the interest rate on savings is \( r = 10\% \). The conversion factor from tokens to euro \(( f \) is 1 euro=25 tokens\) and the tokens spent for consumption enter the payment with a 0.8 weight \((\gamma)\).
For what regards the public sector, the initial debt level \( D_0 \) is 150 tokens for 20 participants and 135 for 18 participants respectively, and it equals the public expenditure amount of each round, so that the required amount of taxes is always 7.5 tokens. The debt interest rate is fixed and equal to \( i = 15\% \). Public debt can be reduced from the second round on by a random amount \( \alpha \) included between 60\% and 90\% but, to directly compare different treatments, the rounds of the debt reductions are accurately chosen, although the participants are not aware of it. Finally, 2 tokens are paid at the end of the experiment for each correct forecast\(^{10} \) \( g_t \). In addition, €3 are paid as a presence contribution to everyone.

Table 2. Experimental parameters, calibrated values for 20 (18) participants

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>( N )</td>
<td>20 (18)</td>
<td>( R )</td>
<td>10%</td>
</tr>
<tr>
<td>( a_t )</td>
<td>10</td>
<td>( \gamma )</td>
<td>0.8</td>
</tr>
<tr>
<td>( T )</td>
<td>15</td>
<td>( h )</td>
<td>6</td>
</tr>
<tr>
<td>( e_t )</td>
<td>7.5</td>
<td>( \mu )</td>
<td>1.2</td>
</tr>
<tr>
<td>( D_0 )</td>
<td>150 (135)</td>
<td>( i )</td>
<td>15%</td>
</tr>
<tr>
<td>( \alpha )</td>
<td>From 60% to 90%</td>
<td>( R )</td>
<td>1.1</td>
</tr>
<tr>
<td>( f )</td>
<td>1/25</td>
<td>Presence</td>
<td>3 euro</td>
</tr>
</tbody>
</table>

The experiment is programmed with z-Tree (Fischbacher, 2007). The participants are Italian-speakers graduate and undergraduate students from University of Trento, who cannot participate to more than one laboratory session. All of them are provided with detailed instructions and experienced with a trial session for each task. Laboratory instructions are reported in Appendix.

### 3.4. Design with tax controls

One of the primary aspects of the experimental design that can influence the debt dynamics and thus subjects’ behaviour is the level of tax compliance: since subjects’

\(^{10}\) The maximum number of extra tokens that can be gained by a subject in such a way is 60.
contribution is free, the total contributed amount depends not only on the fear of a debt reduction, but also on the individual’s predisposition to honesty and the related moral cost (see Rosenbaum et al., 2014).

To control for tax evasion, we reformulate the first treatment with the addition of an exogenous probability of tax auditing: subjects are aware of the fact that if their individual contribution is below the required amount of taxes, they have to pay a fine. In details, the known auditing probability is 25% in each round and, following the structure of the penalties, the fine corresponds to a 5% reduction in the final pay-off. In this case, the formula for the final monetary pay-off becomes:

$P_t(c_t, g_t) = f \cdot (1 - k_1)^{m_1} \cdot (1 - k_2)^{m_2} \cdot \sum_{t=1}^{T} (x_t + g_t)$

which is equal to equation (6) except for $k_2$, the fine percentage amount, and $m_2$, the number of fines.

The difference with the design without tax auditing is in the willingness to limit and explicitly punish the free-riding behaviour, incentivising subjects to pay taxes. However, this setting includes two more elements into the analysis: the risk aversion towards a tax audit and the comparison between the costs and the benefits of debt evasion. Jointly with the burden of the debt reduction and the propensity to honesty, they determine the amount of paid taxes.

From the participants’ point of view, the difference between the treatment without tax controls and the treatment with tax controls is in the probability to get the total pay-off. Whereas without auditing such a probability is 1 regardless of the contributed amount, with tax auditing it becomes 0.75 if the individual contribution is below the amount required to sustain the public expenditure. In formal terms, the expected final pay-off with tax evasion up to round $t$ is:

$VA_t = 0.75C_t + 0.25(1 - 0.05)^{m_t} C_t$
It is possible to notice that the expected cost of a fine is relatively low: for the first fiscal evasion \((m_2 = 1)\) and given a reference amount of 100 tokens, such a cost is just 1.25 tokens; for the second fiscal evasion \((m_2 = 2)\) is 2.44 tokens, and so on. Nevertheless, this structure allows to consider a high auditing probability, keeping the results fully comparable with the no-tax controls case. In fact, realistic auditing rates are between 1.70% and 1.80% according to the latest Italian data\(^{11}\), a rate that is too low for a laboratory experiment.

### 3.5. Treatments

We implement two treatments: an early-shock treatment (T1) and a delayed-shock treatment (T2), both without tax controls and with three exogenous shocks. The exogeneity of the three shocks is fundamental since it avoids introducing any predetermined ad-hoc relationship between the level of public debt and its reduction: it would be misleading to reduce public debt only above a given threshold. As a consequence, the debt reductions should be interpreted as an exogenous political action.

In the first treatment, T1, the first public debt reduction occurs at the beginning of round 3, while in the second treatment, T2, it occurs at the beginning of round 6. The other two shocks are planned at round 9 and 13 respectively. The scope of this differentiation is to formally check whether subjects’ allocations are affected by the time of the first debt reduction. Furthermore, treatment T1 is carried out also with the inclusion of a random mechanism of audit and fines for tax evasion, in order to control for the free-riding behaviour in the experiment as explained in Section 3.5.

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4. Data analysis

For T1 and T2, the two treatments without tax controls, we actually carried out two experimental sessions collecting data from 38 subjects and 40 subjects respectively. For T1 with tax controls, we carried out three experimental sessions collecting data from 56 subjects. However, the data collected through one of these sessions have been excluded from the empirical analysis because the number of participants was low (16) and because the instructions were clearly misunderstood at the beginning of the experiment by a group of participants that did not read the instructions. Therefore, we considered data from two sessions and 40 subjects only.

Considering at first T1 and T2, we constructed one panel dataset for each treatment with the inclusion of the following variables: individual consumption, tax compliance, and savings levels, the two forecast variables for debt reduction (Forecast 1) and debt sustainability (Forecast 2), in addition to public debt, the debt-to-GDP ratio, and public deficits, which are equal for all subjects. Data about consumption, tax compliance, savings, public debt, and the two forecast variables have also been aggregated to construct an aggregate panel dataset based on "macroeconomic" variables, in which the panel units are the experimental sessions without tax controls. In details, consumption, tax compliance, and savings for all participants have been summed up and expressed in terms of endowment to make them comparable throughout different sessions and rounds, while Forecast 1 and Forecast 2 have been averaged to obtain the average market sentiment. The GDP dynamics is entirely given by the dynamics of the aggregate consumption since the experimental GDP is the sum of individual consumptions and of the constant public expenditure\textsuperscript{12}.

\textsuperscript{12} We are aware of the fact that our artificial GDP measure cannot comprise all the aspects of the real-world GDP, but consumption is usually highly correlated with the GDP and our goal is to get insight into the consumption’s side of growth.
Therefore, the three main variables are the outstanding debt — that followed, as anticipated, an uprising dynamics (see Figure 2) — and the consumption and savings levels, whose dynamics is discussed in the next sections. Data have been analysed with Matlab R2016b, while econometric panel models have been estimated with Stata 13.

Figure 2. Public debt, experimental dynamics.

Legend. T11: first session of the first treatment; T12: second session of the first treatment; T21: first session of the second treatment; T22: second session of the second treatment; T1TC1: first session of the first treatment with tax audits; T1TC2: second session of the second treatment with tax audits.

4.1. Qualitative analysis, no tax controls

4.1.1. Treatment 1, results

We carried out two experimental sessions for each treatment; details are reported in Table 3 and Table 4. The first session of T1 was composed by 18 subjects, 8 males and 10 females, whose mean age was 22.39 years. The average final payment was euro 9.06, with a minimum of euro 6 and a maximum of euro 12. The second session was composed by 18 subjects, 9 males and 9 females, whose mean age was 21.72 years, and the average final payment was euro 9.67, with a minimum of euro 6 and a maximum of euro 13. Figure 3 shows the dynamics of average consumptions, collected taxes, and savings for the first session. As one can see, the consumption trend and the savings trend are both upward sloping, while the tax compliance trend is clearly downward sloping. Moreover, there are some differences in the response of these variables to the debt-reduction shocks. The response of consumption is unambiguous: after each shock, the average consumption
increased. The same occurred for the tax compliance level, with the exception of the first early shock, while the dynamics of the average savings level increased after the first and the third shocks, but it decreased after the second (though the general positive trend were never reversed).

The figures depicting the results of the second session of T1 are shown in Figure 4. The general after-shock behaviours of consumption, savings, and tax compliance are comparable to the dynamics of the first session, but the overall dynamics of consumption and savings are rather different. In fact, between the first and the second shock, the participants increased their savings, giving rise to an outstanding upward trend. After the second shock, however, this trend was abruptly reversed, reaching an exceptionally high consumption level and an exceptionally low savings level, then promptly adjusted during the subsequent round. This behaviour is in line with the intuitive optimal strategy for consumption and savings discussed above, even though it must be noticed that the savings level reached a local maximum just before the end of the experiment, while, at the same time, consumption did not increase during the last rounds. Moreover, during the first part of the experiment, savings was certainly excessive.

Table 3. Laboratory sessions, synthesis.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Session</th>
<th>Participant</th>
<th>M</th>
<th>F</th>
<th>Average Age</th>
<th>Average Payment</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1, no tax controls</td>
<td>1</td>
<td>18</td>
<td>8</td>
<td>10</td>
<td>22.39</td>
<td>9.06</td>
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<td></td>
<td>2</td>
<td>20</td>
<td>6</td>
<td>14</td>
<td>21.50</td>
<td>8.15</td>
</tr>
<tr>
<td>T2, no tax controls</td>
<td>1</td>
<td>18</td>
<td>9</td>
<td>9</td>
<td>21.72</td>
<td>9.67</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>18</td>
<td>9</td>
<td>9</td>
<td>21.94</td>
<td>8.50</td>
</tr>
<tr>
<td>T1, tax controls</td>
<td>1</td>
<td>20</td>
<td>9</td>
<td>11</td>
<td>22.35</td>
<td>8.15</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>20</td>
<td>3</td>
<td>17</td>
<td>21.50</td>
<td>8.45</td>
</tr>
<tr>
<td>Discarded</td>
<td>16</td>
<td>5</td>
<td>11</td>
<td></td>
<td>21.44</td>
<td>8.75</td>
</tr>
<tr>
<td>Total</td>
<td>49</td>
<td>81</td>
<td></td>
<td></td>
<td>/</td>
<td>/</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Session</th>
<th>From economic sciences</th>
<th>Right Italian DtG</th>
<th>Italian DtG will increase</th>
<th>Italian DtG, sustainability</th>
<th>DtG, consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1, no tax c.</td>
<td>1</td>
<td>8</td>
<td>8</td>
<td>11</td>
<td>4</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>11</td>
<td>7</td>
<td>16</td>
<td>1</td>
<td>18</td>
</tr>
<tr>
<td>T2, no tax c.</td>
<td>1</td>
<td>13</td>
<td>10</td>
<td>13</td>
<td>6</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>9</td>
<td>8</td>
<td>8</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>T1, tax controls</td>
<td>1</td>
<td>6</td>
<td>10</td>
<td>11</td>
<td>2</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>14</td>
<td>7</td>
<td>13</td>
<td>5</td>
<td>13</td>
</tr>
<tr>
<td>Discarded</td>
<td>12</td>
<td>4</td>
<td>11</td>
<td>1</td>
<td>1</td>
<td>12</td>
</tr>
<tr>
<td>Total</td>
<td>73</td>
<td>54</td>
<td>83</td>
<td>24</td>
<td>24</td>
<td>95</td>
</tr>
</tbody>
</table>
Table 4. Means and standard deviations of savings (S), tax compliance (T) and consumption (C) for each session.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Session</th>
<th>Mean</th>
<th></th>
<th></th>
<th></th>
<th>Mean</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>S</td>
<td>T</td>
<td>C</td>
<td>S</td>
<td>T</td>
<td>C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T1, no tax controls</td>
<td>1</td>
<td>13.94</td>
<td>5.12</td>
<td>12.77</td>
<td>22.67</td>
<td>3.28</td>
<td>5.81</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>14.69</td>
<td>3.91</td>
<td>13.79</td>
<td>22.13</td>
<td>4.06</td>
<td>7.38</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T2, no tax controls</td>
<td>1</td>
<td>16.15</td>
<td>3.02</td>
<td>14.86</td>
<td>23.02</td>
<td>3.93</td>
<td>13.86</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>21.34</td>
<td>2.87</td>
<td>13.96</td>
<td>35.39</td>
<td>3.68</td>
<td>11.33</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T1, tax controls</td>
<td>1</td>
<td>10.68</td>
<td>6.09</td>
<td>12.63</td>
<td>16.59</td>
<td>3.21</td>
<td>10.81</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>11.15</td>
<td>6.88</td>
<td>11.41</td>
<td>12.3</td>
<td>2.35</td>
<td>4.29</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 3. Average consumption, savings, and tax compliance dynamics. Treatment 1 without tax controls, Session 1.

Figure 4. Average consumption, savings, and tax compliance dynamics. Treatment 1 without tax controls, Session 2.

Analysing the aggregate macroeconomic variables expressed in terms of total endowment and depicted in Figure 5 and Figure 6 for the first and the second session respectively, results are even more engaging. For the first session of T1, the consumptions-to-endowment ratio (CtE) is clearly downward sloping, while the savings-to-endowment ratio (StE) is upward sloping and steeper than the former. Furthermore, the CtE ratio strongly increased after each shock, but it decreased immediately after. On the contrary,
the StE ratio remained almost constant or slightly increased in the two rounds that followed the shocks (though to a lower extent than consumption), with the only exception of the last shock, that evidently had the largest impact on savings.

Figure 5. Aggregate consumptions-to-endowment (CtE) and savings-to-endowment (StE) ratios. Treatment 1 without tax controls, Session 1.

On the one hand, the behaviour of the two trends is surprising: though savings did not contribute to the final payment, and though subjects were aware of the fact that the experiment could have finished after round 10, they steadily decreased consumptions and increased savings with respect to their total endowment, so that the highest StE ratio was reached in the last round.

On the other hand, the short-term response of consumption after each shock can clearly be ascribed to a myopic behaviour, indeed immediately corrected in the subsequent round. In general terms, this behaviour is in line with the bomb crater effect discussed by Guala.
and Mittone (2005) and Mittone (2006), and it probably reflects the belief that debt could not have been reduced for two consecutive rounds. Similar conclusions can be achieved for the second session, though the two trends are affected by the break occurred after the second shock.

4.1.2. Treatment 2, results

The second treatment was implemented in two experimental sessions. The first session was composed by 20 subjects, 6 males and 14 females, whose mean age was 21.50 years, and the average final payments was euro 8.15, with a minimum of euro 7 and a maximum of euro 13. The second session was composed by 18 subjects, 9 males and 9 females, whose mean age was 21.94 years, and the average final payments was euro 8.50, with a minimum of euro 6 and a maximum of euro 10.

The patterns discussed for the first treatment emerged also in the two sessions of the second treatment (see Figure 7 for the first session, and Figure 8 for the second session). The consumptions average level responded positively to the three debt shocks but for one round only, whereas savings responded positively too, with only one exception (the second shock of the second session — see Figure 8). Little can be said for the average contribution level, which seems to increase temporarily after the debt-reduction shocks.

The dynamics of the aggregate StE and CtE ratios (Figures 9 and 10) are also comparable to the first treatment, although the two trends are evidently smoother for the first session and steeper for the second session. Note two important caveats, however. Firstly, in the first session the level of the StE ratio exceeded the level of the CtE ratio after the second shock, which means that subjects started to save more when the experiment could have finished. Secondly, in the second session the level of the StE ratio is always higher than the level of the CtE ratio.
Figure 7. Average consumption, savings, and tax compliance dynamics. Treatment 2 without tax controls, Session 1.

Figure 8. Average consumption, savings, and tax compliance dynamics. Treatment 2 without tax controls, Session 2.

Figure 9. Aggregate consumptions-to-endowment (CtE) and savings-to-endowment (StE) ratios. Treatment 2 without tax controls, Session 1.
Finally, T2 has been formally compared with T1 through an ANOVA F-test, to check whether the differences among the means of the treatments were significantly different. Given a commonly adopted 5% significance level, the p-values shown in Table 5 do not allow to reject the null of equal means for consumption, savings, and the gross endowment. On the contrary, the null is rejected for tax compliance, which, however, depends only on the participants’ honesty and free-riding propensity.

Table 5. ANOVA, comparison of T1 and T2 without tax controls.

<table>
<thead>
<tr>
<th></th>
<th>F statistics</th>
<th>P-value</th>
<th>#Obs.</th>
<th>Root MSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Savings</td>
<td>3.11</td>
<td>0.0782</td>
<td>1110</td>
<td>26.3788</td>
</tr>
<tr>
<td>Consumption</td>
<td>0.01</td>
<td>0.9276</td>
<td>1110</td>
<td>10.0587</td>
</tr>
<tr>
<td>Tax compliance</td>
<td>7.93</td>
<td>0.0049</td>
<td>1110</td>
<td>3.8450</td>
</tr>
<tr>
<td>Endowment</td>
<td>1.94</td>
<td>0.1635</td>
<td>1110</td>
<td>26.2384</td>
</tr>
</tbody>
</table>

4.1.3. Forecasts, results

The fundamental part of this experimental design is represented by subjects’ expectations, whose average dynamics are depicted from Figure 11 to Figure 15. Considering the debt-reduction related expectation (Forecast 1), the average number of subjects expecting a debt reduction increased after the first and the second shocks, but it decreases after the third shock, probably reflecting the belief that a further shock was unlikely. On the contrary, subjects reacted differently between the first and the second treatment for what concern
sustainability-related expectations (Forecast 2). Interestingly, when the average perceived sustainability was relatively low, it increased after the shock, but when it was relatively high, it decreased.

Figure 11. Aggregate expectations, fraction of "Debt will be reduced in the next round" (Forecast 1), and average sustainability perception (Forecast 2).
   Treatment 1 without tax controls, Session 1.

Figure 12. Aggregate expectations, fraction of "Debt will be reduced in the next round" (Forecast 1), and average sustainability perception (Forecast 2).
   Treatment 2 without tax controls, Session 1.

Figure 13. Aggregate expectations, fraction of "Debt will be reduced in the next round" (Forecast 1), and average sustainability perception (Forecast 2).
   Treatment 1 without tax controls, Session 2.
4.2. Research question 1

According to the first research question — "Is there a confidence channel linking public debt and the consumption side of economic growth?" — a variation in subjects’ expectations should be associated with a significant variation in the consumption level (note that nothing is said about its sign). To find evidence against or in favour of this argument, we estimated several regression models on the basis of the aggregate variables, linking the growth rate of the CtE ratio (i.e. the experimental GDP growth rate) to the growth rates of the debt-to-GDP ratio and of the forecast variables, then adding several other controls. The basic panel model is thus:

\[
\Delta CtE_{it} = \alpha_i + \beta_1 dCtE_{i,t-1} + \beta_2 dDtG_{it} + \beta_3 dF1_{it} + \beta_4 DR_{it} + \hat{U}_{it}
\]

where \(i\) refers to the experimental session, \(t\) refers to the round or period, \(\Delta CtE_{it}\) is the growth rate of the aggregate consumption-to-endowment, \(\alpha_i\) is the unobserved individual component, \(\Delta DtG_{it}\) is the growth rate of the debt-to-GDP, \(\Delta F1_{it}\) is the first difference of Forecast 1 (debt-reduction forecasts for the following round), \(DR_{it}\) is a dummy variable indicating the rounds of the debt-reduction shocks, and \(\hat{U}_{it}\) is an error term with the usual statistical properties. The other variables that have been considered are \(\Delta StE_{it}\) and \(\Delta TtE_{it}\), the savings and the tax compliance growth rates respectively. For all these variables is possible to reject the null of "Panels contain unit-root" according to two panel unit-root.
Given the limited number of panel units (N = 4) and time periods (T = 15), common GMM estimators such as Arellano-Bond and Arellano-Bover would be inappropriate (their asymptotic properties require N→∞). Therefore, we estimated the pooled-OLS version of
model (11) and adopted the heteroskedastic-robust standard errors\(^\text{13}\). Results are shown in Table 7.

The basic specification is shown in column 1, from which three facts emerge. First, the consumption growth rate and the debt-to-GDP growth rate are linked through a negative significant relationship, entailing that an increase in the debt-to-GDP ratio is associated with a decrease in the consumption-to-endowment ratio. Second, the estimated parameter of \(DR\) is negative and significant: it captures the negative impact of the debt-reduction shock on the level of the CtE ratio. Third, the coefficient of \(dF1\) is negative and significant, thus capturing the inverse relationship between the public debt and the CtE ratio described above. In other words, if subjects’ expectations about a debt consolidation worsen, they react by reducing their consumption level with respect to their endowment.

The second column of Table 7 adds two explanatory variables: the savings-to-endowment (StE) and the taxation-to-endowment (TtE) growth rates. The former variable is significant and negative, implying that an increase in the StE ratio is associated with a decrease in the CtE ratio in the subsequent round, a fact that stems directly from the dynamics of the two variables described in the qualitative analysis. The latter, instead, is not statistically significant, thus underlying that the dynamics of the TtE ratio is mainly influenced by individual behavioural aspects. Noteworthy, the significance and the sign of the other variables included in the basic model do not change, with the only exception of \(dF1\), whose estimated coefficient is not significant. The lagged dependent variable, instead, is not significant.

The third column of Table 7 adds an interaction term between the growth rate of the debt-to-GDP ratio and \(dF1\) in order to describe their joint impact on \(dCtE\). Estimation

\(^\text{13}\) It must be underlying, however, that the Arellano-Bond and the Arellano-Bover estimators approximately led to the same estimated coefficients of the pooled-OLS estimator.
results confirm the non-significance of \( dF1 \), but its negative impact on the dependent variable is fully captured by the interaction term. At the same time, the sign and the statistical significance of the other variables are not affected. This model can reveal the existence of a scale effect between \( dDtG \) and \( dF1 \), according to which a large variation in both the debt-to-GDP ratio and the expectations of a debt reduction entails a larger negative impact on \( CtE \).

On the basis of this analysis, the econometric specification used to describe the relationship between the variables of interest is \( CM1 \) (Table 6, column 4), a specification that do not incorporate the lagged \( dTtE \) (never significant) and \( dF1 \). With respect to the model in column 3, the only difference is in the magnitude of the coefficient of the interaction term, which is affected by the exclusion of \( dF1 \).

According to this model, the existence of a confidence channel between consumption and public debt seems reasonable, a channel that associates a worsening in the expectations of a debt reduction — or, in general, to the expectations of worse fiscal measures — to a reduction in the consumption level.

**4.3. Research question 2**

The previous analysis is extended to incorporate the concept of perceived debt sustainability, directly elicited during the experiment with the debt-sustainability expectation in order to answer to the second research question — "Does the perceived debt sustainability affect the choices of the subjects?". The variable of interest is thus \( Forecast_2 \), whose rate of change is indicated with \( dF2_u \). The analysis takes two directions: we expand equation (11) to incorporate the new forecast variable, and we employ the same strategy adopted in Section 2 to describe the behaviour of the aggregate StE ratio and \( CtE \) ratio.
The first part of the analysis aims at identifying the impact of the perceived sustainability on the consumption level, alone, and jointly with the debt-reduction forecast (F1). Therefore, equation (10) is developed to incorporate \( dF2_\mu \)

\[
(11) \quad dCtE_\mu = \alpha_i + \beta_d dCtE_{\mu-1} + \beta_s dDtG_\mu + \beta_d dF2_\mu + \beta_d dF1_\mu * dF2_\mu + \beta_s DR_\mu + \hat{\epsilon}_\mu
\]

and then \( dF1_\mu \) and \( dF2_\mu \) together:

\[
(12) \quad dCtE_\mu = \alpha_i + \beta_d dCtE_{\mu-1} + \beta_s dDtG_\mu + \beta_d dF2_\mu + \beta_s (dDt_\mu * dF2_\mu) + \beta_s DR_\mu + \hat{\epsilon}_\mu
\]

where \( (dDt_\mu * dF2_\mu) \) indicates the interaction term between the two variables. Estimation results are shown in Table 8.

The first column, which refers to equation (11), confirms the negative impact of debt on consumption, but \( dF2_\mu \) is not statistically significant. This result changes once the model is expanded to incorporate other explanatory variables. Column 2 shows that \( dF2_\mu \) becomes positive and significant if an interaction term is added: a positive variation in the perceived sustainability has a positive impact on the consumption level, which is partly compensated by the negative sign of the interaction term.

Column 3 reports the estimation of equation (12), and shows that the previous results, in terms of sign and significance, are confirmed. In fact, not only the coefficients of \( dF2_\mu \) and of the interaction term are comparable to those of the second column, but also \( dF1_\mu \) is not statistically significant as in Table 8. With respect to \( dF2_\mu \) and its interaction term, this result is confirmed by the model in column 4, in which the significant interaction term of \( dF1_\mu \) is added. On the basis of these results and out of consideration of the adjusted \( R^2 \), the chosen model is \( CM2 \) (column 5), which does not include \( dF1 \) and, as before, \( dTtE \).

Table 8. RQ2, panel estimation for dCtE.
The second part of the analysis aims at identifying the impact of the perceived sustainability on savings. Following the same steps, for brevity only the chosen model (CM3) is reported in Table 9.

By looking at the estimation results, a statistically positive relationship links $dDtG_{it}$ and $dStE_{it}$, entailing that an increase in the debt-to-GDP ratio is associated with an increase in the savings-to-endowment ratio. As expected, the same occurs for $dF1$: if the expectations about a debt reduction worsen, the savings level increase. On the other hand, $dF2_{it}$ is not statistically significant, but the related interaction term with $dDtG_{it}$ shows a possible non-linear (negative) relationship of the perceived sustainability, which depends on $dDtG_{it}$ itself.
The negative sign of $DR_u$ reflects the already recognised *bomb crater effect*, according to which a debt shock is usually followed by a decrease in the savings level and an increase in the consumption level. This short-life effect could be seen as supporting the expansionary fiscal consolidation hypothesis, according to which a debt consolidation is followed by an expansion in the aggregate demand, but in fact it is only an experimental phenomenon (see Guala and Mittone, 2005; Mittone, 2006).

Finally, it can be observed that the negative relationship in models $CM1$ and $CM2$ between consumption and savings arises anew between savings and consumption, thus confirming the reverse relationship between the two variables. Moreover, the relationship between $dTtE_{it}$ and savings within this framework is not theoretically defined. For this reason, and since the variable was not significant, $dTtE_{it}$ has been excluded from model $CM3$.

In conclusion, we have shown that an increase in the perception of a debt reduction is associated with a decrease in the consumption-to-endowment level and an increase in the savings-to-endowment level, while an increase in the perceived sustainability is associated with an increase in the consumption-to-endowment level, but it appears to have no impact on the savings-to-endowment level.

These findings are in line and expand the comprehension of the qualitative analysis: a situation of increasing public debt in which people might be forced to pay an uncertain amount and to bear the cost of the debt reduction is associated with relatively high and increasing aggregate savings and decreasing aggregate consumptions. Moreover, an increase in the debt-reduction expectations and a decrease in the perceived debt sustainability are linked to a reduction in the CtE ratio and an increase in the StE ratio, as predicted by Hypothesis 2.
### Table 9. RQ2, panel estimation for dStE.

<table>
<thead>
<tr>
<th>Specification</th>
<th>CM3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dep. Var.</td>
<td></td>
</tr>
<tr>
<td>dStE(-1)</td>
<td>-0.1779 (0.1571)</td>
</tr>
<tr>
<td>dDtG</td>
<td>0.8800*** (0.2133)</td>
</tr>
<tr>
<td>dF1</td>
<td>0.0693* (0.0352)</td>
</tr>
<tr>
<td>dF2</td>
<td>0.1213</td>
</tr>
<tr>
<td>dCtE(-1)</td>
<td>-0.2864** (0.1308)</td>
</tr>
<tr>
<td>dTtE(-1)</td>
<td>-</td>
</tr>
<tr>
<td>DR</td>
<td>-0.4200*** (0.0702)</td>
</tr>
<tr>
<td>dDtG(-1)*dF1</td>
<td>-0.2012 (0.1951)</td>
</tr>
<tr>
<td>dDtG(-1)*dF2</td>
<td>-0.5301* (0.3128)</td>
</tr>
<tr>
<td>Const.</td>
<td>-0.0056 (0.0545)</td>
</tr>
<tr>
<td>#Obs.</td>
<td>52</td>
</tr>
<tr>
<td>Adj. R²</td>
<td>0.5104</td>
</tr>
</tbody>
</table>

Notes: ***, ** and * indicate statistical significance at 1%, 5% and 10% level respectively. All robust standard errors are in parentheses.

### 4.4. Analysis of residuals

First, the Arellano-Bond panel test has been applied to test for the presence of first order and second order residuals autocorrelation, which can bias the standard errors and affect the other statistical tests, but the null of no serial correlation has not been rejected.\(^\text{14}\)

On the contrary, the p-values of the pooled Shapiro-Wilk test have allowed to reject the null of normality. This test, however, has been repeated for the same series without the outliers referred to the post-shock reactions and, in this case, normality has not been rejected at 5% for CM2 and CM3 and at 1% for CM1. Therefore, it is possible to say that,

\(^{14}\) Though the Arellano-Bond test statistic requires \(N\rightarrow\infty\), the results can give an indication of autocorrelation.
even with $DR_{it}$, the estimated models are unable to capture the impact of the shocks, both in terms of consumption and savings.

Then, the estimation of the specifications in Table 7, 8, and 9 have been repeated excluding the first two observations for each variable in order to check whether the results were influenced by the number of observations and whether they were highly determined by the behaviour of the participants at the beginning of the experiment, when they are commonly deemed to be still on a learning path. The estimation results confirmed the previous findings; in fact, the estimated coefficient did not change much, both in terms of significance, sign, and value.

Finally, we have estimated the chosen models without including the constant term. The magnitude of the estimated coefficients changed, naturally, but the sign and the significance levels were not much affected. Since the constant is almost always significant, it interacts with $DR_{i}$, and it does not affect the analysis, we have decided to keep it.

4.5. Qualitative analysis, tax controls

Despite being freely possible to avoid paying taxes, during the four experimental sessions without tax controls it was observed a positive average contribution level that may reflect both honesty propensity and concern about the cost of a debt reduction. However, average contributions fell steadily during each of the four sessions as a consequence of the rise in the free-riding behaviour that had the direct consequence of feeding the public debt uprising dynamics. To examine whether this behaviour had an impact on the subjects’ choices, we implemented the first treatment with the fiscal audits’ mechanism explained in Section 3.5. The details about the two sessions are reported above, in the last two rows of Table 3.

The results of the first session with tax controls are shown in Figure 15 and Figure 16. They are in line with the previous discussion and, in particular, with the results of the second session of T1 (Figure 4): the general after-shock response of consumption and tax
compliance is positive, while the response of savings is positive except for the second debt shock, when participants increased their consumption level permanently while they kept the level of savings low. Therefore, the second debt-reduction shock coincided with a break: between the first and the second shock, subjects constantly increased their savings, giving rise to an upward trend that was reversed after the second shock (Figure 16). This aggregate behaviour is the closest to the intuitive optimal strategy for consumption and savings, even though the CtE ratio decreased after the time break and the StE ratio was on a slightly upward trend. Also the average forecast variables followed the path already recognised in the previous sessions: looking at Figure 17, the perceived sustainability (Forecast2) decreased constantly with the only exception of a temporary increase after the second debt-reduction shock, while the average perceived probability of a debt reduction (Forecast1) is less informative in this case but, as usual, it increased after the first and the second shock and it decreased after the third one, probably reflecting the approaching of the end of the experiment. The second session with tax controls confirms these results. Starting from Figure 20, the dynamics of the average Forecast1 does not show relevant differences with respect to the previous analysis, while the dynamics of Forecast2 is more shock-dependent. At the same time, Figure 19 depicts a situation that is in contrast with the one depicted in Figure 16: the StE ratio steadily increased, but it became greater than the CtE ratio in the second part of the experiment, while at the beginning it was much lower. However, though the dynamics of savings did not seem to be affected by fiscal audits, what emerges from both Figure 17 and Figure 20 is the fact that the StE ratio seems translated downwards with respect to the no-tax-controls sessions. In fact, by looking at the first two columns of Table 4, the average level of savings in the two sessions with tax controls is not only lower than in the sessions without tax controls, but also lower than the average consumption, which remained comparable with the previous average values.
Recapitulating, both sessions contributed to show three outstanding results: a) tax evasion was not totally eradicated, but it was curbed and the decreasing trend observed for paid taxes disappeared; b) on the whole, the results are comparable with the four sessions without tax controls; c) the level of the CtE ratio does not seem to be strongly affected by tax controls, but the level of the StE ratio appears to be lower.

Figure 15. Average consumption, savings, and tax compliance dynamics. Treatment 1 with tax controls, Session 1.

Figure 16. Aggregate consumptions-to-endowment (CtE) and savings-to-endowment (StE) ratios. Treatment 1 with tax controls, Session 1.

Figure 17. Aggregate expectations, fraction of "Debt will be reduced in the next round" (Forecast1), and average sustainability perception (Forecast2). Treatment 1 with tax controls, Session 1.
4.6. Research question 3

To study the influence of the average higher amount of taxes paid by the participants as a consequence of the controls on tax evasion, we constructed a dataset formed by the four
sessions without tax controls and the two sessions with tax controls. To compare the experimental sessions, we excluded the forecast variables and we included, beyond the growth rate of the \(dT_{tE_t}\) ratio, an interaction term meant to capture the impact of the tax-control: \(dT_{tE_t} \times D\), where D is a dummy variable equals to 1 for the two sessions with tax controls and equals to 0 for the experimental sessions without tax controls. Results are shown in Table 10.

As it can be observed, the interaction term on which we focus is not statistically significant for the \(dCtE\) regression (model CM2b), but it is slightly significant and negative for the \(dStE\) regression (model CM3b). Beyond statistical significance, the negative sign reflects the conclusions of the qualitative analysis.

On the whole, subjects compensated for the higher contributions due to the fiscal audits by reducing savings. This result sheds light on a possible dangerous condition, represented by a situation in which people, given their endowment, sacrifice savings in order to pay relatively higher taxes and to maintain a certain level of consumption. In such a case, however, subjects’ endowment grows slower and they are more exposed to unexpected shocks, beyond hampering future consumption. This fact is also confirmed by the values shown in Table 4 — it is evident that the average savings in the two sessions with tax controls are lower than in the other sessions — and from Figure 21: whereas the two linear interpolation functions for \(dCtE\) overlap (panel B), the interpolation functions referring to \(dStE\) go in opposite directions (panel A): the line that refers to the experimental sessions with tax controls has slightly negative slope, while the line that refers to the experimental sessions without tax controls has positive and statistical significant slope.

This finding is also in line with the common impact of taxation on the savings rate, according to which an increase in income taxes negatively affects the savings rate (see for instance Zee and Tanzi, 1998). Accordingly, the adopted experimental design seems to be empirically robust as it can capture this phenomenon even in a quite complex framework.
In conclusion, the level of the StE ratio of the two sessions in which subjects faced a tax control mechanism are relatively lower than the level of the StE ratio registered without such a mechanism, thus making subjects relatively poorer in the long-run and more exposed to the shocks.

Figure 21. Linear relationships between dStE and dTtE (panel a) and dCtE and dTtE (panel b). Sessions without tax controls (black) and sessions with tax controls (red). (a)
4.7. Questionnaire and risk aversion, results

Subjects’ knowledge about the topic was assessed at the end of the experiment through a number of questions (Table 1). All in all, the knowledge of the Italian financial situation looks poor, as the right 2017 Italian debt-to-GDP ratio slot (120-140%) was selected by only 41.54% of the participants. This should be seen as an advantage that confirms that the participants could not be considered as "experts". Moreover, to check whether this fact had an impact on the aggregate results discussed in the previous sections, we included in specifications CM1 and CM2 two explanatory variables15: the percentage of students from economic sciences ("Economics") and the percentage of right answers to the Italian actual debt-to-GDP question ("Right Italian DtG"). Results in Table 1 confirm that neither of these variables is significant. Nevertheless, the awareness of a relatively problematic Italian situation emerges from other two questions: 63.85% of the participants believes that the Italian debt-to-GDP ratio will increase in the near future, while only 18.46% believes that it is sustainable. Noteworthy, 73.08% of the participants reckons that the

15 Because of collinearity, the two variables were included separately.
public debt level somehow affects the private consumption level, but this result might depend on the experiment itself and would deserve further research.

For what concern the degree of risk aversion, the Holt and Laury task has always led to an average degree of risk aversion included between 0.61 and 0.75, thus confirming that subjects were, on average, mid risk averse, a result that is in line with the savings and consumption behaviour observed in the experiment. The results for each session and the distribution of the degree of risk aversion are shown in Figure 22.

Table 11. Panel estimation for dCtE and dStE, further controls.

<table>
<thead>
<tr>
<th>Model</th>
<th>CM1c</th>
<th>CM3c</th>
<th>CM2d</th>
<th>CM3d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dep. Variable</td>
<td>dCtE</td>
<td>dStE</td>
<td>dCtE</td>
<td>dStE</td>
</tr>
<tr>
<td>Explanatory variables</td>
<td>[...]</td>
<td>[...]</td>
<td>[...]</td>
<td>[...]</td>
</tr>
<tr>
<td>Economics</td>
<td>0.0404</td>
<td>-0.0657</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>(0.1529)</td>
<td>(0.1872)</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Right Italian DtG</td>
<td>-</td>
<td>-</td>
<td>-0.6084</td>
<td>-0.1397</td>
</tr>
<tr>
<td>(0.3890)</td>
<td>(0.5679)</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>#Obs.</td>
<td>52</td>
<td>52</td>
<td>52</td>
<td>52</td>
</tr>
<tr>
<td>Adj. R²</td>
<td>0.8071</td>
<td>0.4993</td>
<td>0.8260</td>
<td>0.5001</td>
</tr>
</tbody>
</table>

Figure 22. Holt and Laury task, average degree of risk aversion, standard deviations, and overall distribution.

<table>
<thead>
<tr>
<th>Session</th>
<th>T1, 1</th>
<th>T1, 2</th>
<th>T2, 1</th>
<th>T2, 2</th>
<th>TC, 1</th>
<th>TC, 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.6167</td>
<td>0.6722</td>
<td>0.6500</td>
<td>0.7000</td>
<td>0.6889</td>
<td>0.7444</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>0.2771</td>
<td>0.1965</td>
<td>0.1948</td>
<td>0.2401</td>
<td>0.1906</td>
<td>0.1854</td>
</tr>
</tbody>
</table>
5. Conclusions

This paper studied the relationship between public debt and the consumption side of economic growth from an experimental macroeconomics point of view, by analysing whether consumers’ expectations about public debt and the uncertainty about the fiscal behaviour of the government affect their decisions in terms of consumption and savings choices.

We implemented a laboratory experiment in which the participants earned an income to be allocated between consumption, savings, and voluntary taxation for an unknown number of rounds. The core of the experiment was represented by a public-good game with threshold: taxation was used to cover a given level of public expenditure, equally distributed to the participants at the beginning of each round. If the collected amount of taxes was lower than what was required, the government had to ask for an amount of exogenous debt in order to sustain its public expenditure. Then, at the beginning of each round the outstanding amount of public debt could have been reduced by accessing subjects' savings. Within this framework, we elicited subjects' expectations about their perceived debt sustainability and future debt reduction.

Conscious of the limits of this experimental design, we do not want to overstate its external validity, that is limited though the design is, in our opinion, empirically robust. In fact, the dynamics of public debt is determined by tax evasion which simply implies, as in reality, that the equality between government revenues and government spending does not hold. Nonetheless, results shed light on the existence of a confidence channel between public debt, fiscal policies, and consumptions, broader than the expectations channel of Sutherland (1997). As a matter of fact, findings have showed that subjects' consumption and savings decisions seem to be affected by their debt expectations and by the uncertainty about the political intervention and its cost. As the public debt and the debt-to-GDP ratio increase, subjects reduce their consumption and increase savings with respect to their
endowment, fearing the burden that they would bear if the government intervened to reduce the soaring public debt. This behaviour is not only explained by their expectations on a debt reduction, but also by their perceived debt sustainability: econometric estimations show that both forecast variables are significant and coherent with this conclusion. On a short-term perspective, instead, what we commonly observed is an increase in consumption and a decrease in savings after a debt-reduction shock, in line with the experimental *bomb crater effect*.

Summarising, a soaring public debt within an uncertain political framework triggered a combination of increasing savings and decreasing (or at least constant) consumption levels, influenced also by expectations that were found to be related to subjects’ decisions and that affected the experimental economic growth. The introduction of a tax evasion control did not alter the conclusions and showed that the participants sacrificed savings rather than consumption in order to bear a higher level of taxes, ending up being more exposed to the exogenous shocks.

All these elements shed light on the existence of a confidence channel that, in uncertain periods like during the Sovereign Debt Crisis, might have negatively affected economic growth.
Appendix

Laboratory instructions

General instructions

Good morning and thank you for having accepted to join this experiment. Please, do not talk with the other participants, remove your personal things from the desk and turn off your mobile phone. Pay attention to the experimental instructions and, should you have any question, raise your hand and ask the experimenters.

You are about to join a study about decisions and expectations in an economic framework. Your answers will be anonymous, and the experimenters will not be able to associate them to your name.

During the experiment you could gain an amount of money that will depend on your decisions and on the decisions of the other participants. Your gains will be expressed in tokens and then converted in Euro.

You will also gain euro 3 for the participation.

At the end of the experiment you are required to fill a questionnaire.

Your decision

The experiment consists of many rounds, between 10 and 20. This implies that it could finish at any time between round 10 and round 20, and it could not go further than round 20.

At the beginning of the experiment you will join a task that determines the constant number of tokens that you will receive in each round. This amount is your income.

Your total endowment is formed by your income and a governmental transfer which is computed as described below. You task is to allocate your total endowment between three choices: consumptions, taxation, and savings.
- Round 1.

1) Publix expenditure and taxation:
The total amount of public expenditure (E) is constant and equal to 150 tokens per round. Taxation is required to cover it. The individual amount that you should pay is shown on the computer screen, but you are free to decide how much to disburse.

**WITHOUT FISCAL AUDITS:**
The government will not check the paid amount and you cannot be sanctioned.

**WITH FISCAL AUDITS:**
The government will randomly check the paid amount and, if the taxes you paid are lower than the required amount, you will be sanctioned by a reduction of 5% of your final payment.

If the collected amount is lower than E=150, let’s say F<150, the government must finance the remaining amount of public spending (E-F) by asking for a loan with an interest rate of 15% for each round. Therefore, if the collected amount in round 1 is, for instance, F=50 tokens, the borrowed amount in round 1 is $D = (150-50) = 100$ tokens. Interests are accrued in the next round and are equal to $100 \times 0.15 = 15$ tokens.

The amount $E+D=150$ tokens will then be multiplied by 1.2 (120%) and will be equally distributed to all the participants. Therefore, each participant will receive $(150 \times 1.2) / 20 = 9$ tokens. If the collected amount is higher than 150 tokens, that is F>150, F will be multiplied by 1.2 and distributed among all the participants at the beginning of the next round.

Period 1 public expenditure is financed with debt only; thus, $D_1=E=150$ tokens.

In summary:
Example: Let’s consider a total contribution of 80 tokens. The amount of debt is \((150-80)=70\) tokens. At the beginning of the next round, each participant will receive \((150 \cdot 1.2)/20=9\) tokens, independently from the individual amount of paid taxes.

2) Consumption and savings:
You can also spend your total endowment to buy a dummy basket of goods or you can save it to increase your endowment in the next rounds.
Your consumption expenditure will determine your final payment as explained below (see "Final payment"). On your savings, instead, you will gain interests according to a fixed interest rate (10% per round). In this manner, if you save 10 tokens, you will get \(10 \cdot 1.1=11\) tokens in the next round.
All your financial results are shown and described on the screen.

- From round 2 to the end of the experiment.
From round 2 to the end of the experiment you are again required to allocate you total endowment between consumption, taxation, and savings. The experiment will finish between round 10 and round 20.

Government debt reduction
The amount that the government must borrow to sustain public expenditure feeds public debt. The government can decide to reduce the total amount of debt at any time after round 1 according to a given probability \(p\). This could never occur or occur at every round.
To reduce its debt, the government uniformly withdraws the required amount from the total amount of savings. Two consequences are possible:
• If your total amount of saved tokens is higher than the required amount, your savings will be reduced by this amount.

• If your total amount of saved tokens is lower than the required amount, your savings will go to 0 and your final payment will be reduced by 15% (15 tokens for 100 tokens). In this case, government debt will be reduced by a lower than expected amount.

Example: If the individual number of tokens required to reduce government debt is 20 tokens and your total saving is 30 tokens, it will be reduced to (30-20)=10 tokens. If the individual number of tokens required to reduce government debt is 20 tokens and your total saving is 15 tokens, it will be reduced to 0 tokens and your final payment will be reduced by 15%. Thus, if, for instance, you have accumulated 100 tokens, you will lose just 15 tokens, in this case less than the 20 tokens required for the debt reduction.

Forecasts
At the end of each round you are requested to answer to a couple of questions:

Do you believe that public debt will be reduced by the government in the next round?

If you believe that government debt will be reduced, you must insert 1; if you believe that public debt will NOT be reduced, you must insert 0.

How many participants do you believe that think that the actual level of government debt is sustainable?
where sustainability means the future ability of the government to repay its debt or, in other words, the ability of current and future earnings to cover the current level of public debt. You will gain 2 tokens at the end of the experiment for each correct answer. You will gain 0 tokens for each wrong answer. **Should you have any question, please rise your hand and ask the experimenters.**

**Example:** If you believe that none of the participants (you excluded) believes that public debt is going to be reduced, you must insert 0. If you believe that 5 participants (you excluded) believes that public debt is going to be reduced, you must insert 5.

**Final payment**

Your final payment is determined by the sum of your consumptions expenditures whenever that amount is higher than 6 tokens per round (subsistence level of consumption). If the consumption expenditure of one period is lower than 6 tokens, it will not be considered for the final payment and it will be reduced by 15% as explained above. This amount is then adjusted according to:

- The number of penalties.
- The number of right forecasts.

Savings and public expenditure do not contribute to the final payment, which is, however, increased by 2 tokens for each correct answer to the two questions shown above. Then, the total amount of tokens is converted in Euro according to the conversion rate (25 tokens=1 Euro). The formula for the final payment can thus be summarised as:

\[
P = f(1 - k_1)^m(1 - k_2)^n \sum_{t=1}^{T} (0.8w_t + g_t)
\]

Where \( P \) is the final payment expressed in Euro, \( f = 1/25 = 0.04 \) is the conversion rate, \( k_1=15\% \) is the penalty for a level of consumption lower than 6 tokens or because the total amount of savings is lower than the amount required for the debt reduction, \( k_2=5\% \) is the
penalty for tax evasion, and m and n are the numbers of the two penalties respectively, T is the number of rounds, \( w_t \) is the consumption expenditure of round \( t \), and \( g_t \) is a binary variable that indicates the amount received for each correct forecast (0 or 2 tokens).

**Example:** If the experiment ends after 10 rounds and your consumption expenditure has been constant and equal to 10 tokens, the number of tokens that contributes to the final payment is \( 0.8 \times 10 \times 10 = 80 \) tokens. If, however, you have accumulated two 15% penalties, the final payment is reduced to \( 80 \times (1 - 0.15)^2 = 68 \) tokens.

**Final task**
As soon as everyone has finished the experiment and before the final questionnaire, you will join one last task. For this task, you have a screen showing ten rows. Each row is a paired choice between Option A and Option B. You will need to think about your preference between these two options for each row of the table, but only one of the rows will be used to determine your earnings.

After you have entered your decision, the computer will randomly determine which of the ten rows will count toward your earnings. The computer will then randomly determine your earnings according to the choice that you made, either Option A or Option B, for the row that it selected. This amount will be added to your earnings from the first part of the experiment and paid to you in cash at the end of the experiment.

You will need to think about your preference between Option A and Option B in all ten rows. Only one of the rows will end up affecting your earnings, but you will not know in advance which one that will be. Each row has an equal chance of being used.
**Example:** Option A presents a 10% probability of winning 20 tokens and a 90% probability of winning 16 tokens. At the same time, Option B presents a 10% probability of winning 38.5 tokens and a 90% probability of winning 1 token.

Should you have any question, please rise your hand and wait for the experimenters.

**Strategic analysis**

Can an optimal strategy be identified? To study the rational choices from the participant’s perspective, this section focuses on two generic subsequent rounds \((t, t+1)\) after round 9, when the experiment can finish, and we exclude the forecasts’ prize. To comprise these two aspects of our framework that are of interest for the participants, i.e. the future experimental endowment and the consumed tokens that determine the final monetary payment, let me define \(C_{t-1} = \sum_{j=1}^{t-1} c_j\) as the amount of consumed tokens accumulated up to round \(t - 1\), \(D_t\) as the outstanding amount of debt at round \(t\), and \(W_t\) as the sum of the stock of consumed tokens that contributes to the final payment and the subject’s income at round \(t\). \(W_t\) is thus given by:

\[
W_t = C_{t-1} + \left(a_t + \frac{\mu E}{N}\right) + S_{t-1}R \equiv C_{t-1} + Y + S_{t-1}R
\]

where \(Y \equiv a_t + \frac{\mu E}{N}\) is the sum of the individual income and of the individual public transfer, which is constant if the total contribution is assumed to be at most equal to the public expenditure \((E_t = E \forall t)\). A representative subject, say subject \(i\), should decide how to allocate \(Y + S_{t-1}R\) optimally to maximise his final monetary pay-off, which is entirely determined by the stock of consumption.
At round $t$, a further round $t + 1$ can be reached with probability $q$, while with probability $1 - q$ the experiment ends. If this is the case, each subject should consume all the endowment (savings and taxes do not contribute to the final payment), and $C_{it}$ is just:

\[(A.2) \quad C_{it} = C_{it-1} + (Y + S_{it-1}R) = C_{it-1} + c_{it}\]

If, on the contrary, the experiment continues, participants face an uncertain situation in which public debt can be reduced with probability $p$ at the beginning of round $t + 1$, thus affecting their savings. At the same time, the new flow of income and the flow of interests on savings are received. In formulas, if public debt is not reduced, $W_{it+1}$ can be written as:

\[(A.3) \quad W_{it+1} = C_{it-1} + c_{it} + Y + S_{it}R\]

$S_{it}$ being period $t$'s savings, namely

\[(A.4) \quad S_{it} = Y - c_{it} - T_{it}\]

If, instead, public debt is reduced, equation (A.3) becomes:

\[(A.5) \quad W_{it+1} = C_{it-1} + c_{it} + Y + S_{it}R - \frac{\alpha D_{it}}{N}\]

where it should be recognised that, given $D_{t-1}$, $D_{t}$ is an endogenous variable determined by the individual contributions at round $t$. Indicate with $T_{i}'$ the total amount of subjects $j$'s collected taxes, i.e. $T_{i}' = \sum_{j=1}^{N} T_{ij}$, and with $T_{i}''$ the collected amount if everyone pays exactly the required amount of taxes. Two extreme cases can be identified according to the overall contribution level:

a) Subject $i$ is the only participant who pays taxes at round $t$. Hence, $T_{i}' = 0$ and equation (A.5) becomes:

\[(A.6) \quad W_{it+1} = C_{it-1} + c_{it} + Y + S_{it}R - \frac{\alpha(D_{t-1} + E - T_{it})(1+i)}{N}\]

b) Everyone pays the required amount of taxes:
The actual contribution level $T'_i$ is likely to be included within these two extremes. The strategic tree depicting these outcomes is shown in Figure A.2.

Considering equation (A.4), the expected value of $W_{a+1}$ to be maximised is, without penalties:

$$E_i[W_{a+1}] = (1-q)(C_{a-1} + Y + S_{a-1}R) + q(1-p)(C_{a-1} + c_a + Y + (Y - c_a - T_a)R) +$$

$$+ qp \beta (C_{a-1} + c_a + Y + \max \{ (Y - c_a - T_a)R - \frac{\alpha(D_{a-1} + E - T_a)(1+i)}{N}, 0 \}) +$$

$$+ qp(1-\beta)(C_{a-1} + c_a + Y + \max \{ (Y - c_a - T_a)R - \frac{\alpha(D_{a-1} + E - T_a - T''_a)(1+i)}{N}, 0 \})$$

where $\beta$ is the subjective probability associated to case (a) and $1-\beta$ is the subjective probability associated to case (b).

On the one hand, the strategic component of the experiment can be seen by computing $\frac{dE_i[W_{a+1}]}{dT_a}$. In the most general case in which $T'_i$ is included between the two extremes, the partial derivative is:

$$\frac{dE_i[W_{a+1}]}{dT_a} = -q(1-p)R + (qp)\max \{ -R + \frac{\alpha(1+i)}{N} \left( 1 + \frac{dT'_i}{dT_a} \right), 0 \}$$

Where $\frac{dT'_i}{dT_a} \in [0,1]$ captures the strategic relationship between the choice of $i$ and the choices of the other participants\(^{16}\) or, in other terms, the correlation between the choice of $i$ and the choices of all the others. Equation (A.9) can be either positive or negative but, given the calibration presented in the previous section with $N = 20$, the $\max \{ \}$ term in (A.9) is 0; thus, equation (A.9) reduces to:

\(^{16}\) If 0, subject $i$ is the only one who pays taxes; if 1, everyone pays taxes.
\( \frac{dE_t[W_{it+1}]}{dT_{it}} = -q(1-p)R < 0 \)

which is clearly negative. Therefore, it is always convenient to pay less taxes, until 0: taxes are not paid in the Nash equilibrium.

On the other hand, the analysis of \( c_i \) and \( S_t \) does not allow to precisely identify how much to save and how much to consume, beyond the imposed consumption subsistence level. Nonetheless, equation \((A.8)\) can be evaluated: since \((D_{t-1} + E - T_{it}) > (D_{t-1} + E - T_{it} - \sum_{j=1, j \neq i}^{N} T_{jt})\), three scenarios can be detected with respect to the savings level \( S_t \):

- **Scenario 1**: the amount of \( S_t \), say \( S_1 \), can cover the worst reduction in public debt:

\[
\max\{S_t R - \frac{\alpha(D_{t-1} + E - T_{it} - T''_{it})(1+i)}{N}, 0\} > 0, \max\{S_t R - \frac{\alpha(D_{t-1} + E - T_{it})(1+i)}{N}, 0\} > 0
\]

- **Scenario 2**: the amount of \( S_t \), say \( S_2 \), can cover the reduction in public debt only if everyone pays taxes:

\[
\max\{S_t R - \frac{\alpha(D_{t-1} + E - T_{it} - T''_{it})(1+i)}{N}, 0\} > 0, \max\{S_t R - \frac{\alpha(D_{t-1} + E - T_{it})(1+i)}{N}, 0\} = 0
\]

- **Scenario 3**: the amount of \( S_t \), say \( S_3 \), cannot cover any reduction in public debt:

\[
\max\{S_t R - \frac{\alpha(D_{t-1} + E - T_{it} - T''_{it})(1+i)}{N}, 0\} = 0, \max\{S_t R - \frac{\alpha(D_{t-1} + E - T_{it})(1+i)}{N}, 0\} = 0
\]

Starting from Scenario 1, equation \((A.8)\) becomes:

\(\text{(A.11)}\)

\[
E_t[W_{it+1}] = C_{it-1} + (1-q)S_{t-1}R + Y(1+qR) + c_i q(1-R) - T_{it}q\left(R - \frac{p\alpha(1+i)}{N}\right) + q\alpha\left(\frac{(D_{t-1} + E - (1-\beta)T''_{it})(1+i)}{N}\right)
\]

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which corresponds to the equation of a straight line in the plane \((E_t[W_{t+1}], c_t)\), with intercept
\[
l_1 = \left[ C_{t-1} + (1-q)S_{t-1}R + Y(1+qR) - T_0 \left( R - \frac{\alpha(1+i)}{N} \right) - q \alpha \left( \frac{(D_{t-1} + E - (1-\beta)T^n)(1+i)}{N} \right) \right]
\]
and slope
\[
l_1 = q(1-R).
\]

Penalties can now be introduced into the analysis: if savings is not sufficient to cover the debt reduction, Scenario 2 and Scenario 3 entail a penalty on the amount \(C_{t-1} + c_t\), that is reduced by a factor \(k\) to \((1-k)(C_{t-1} + c_t)\). Thus, \(E_t[W_{t+1}]\) for Scenario 2 is given by:

(A.12) \[ E_t[W_{t+1}] = C_{t-1}(1-qp\beta) + (1-q)S_{t-1}R + Y(1+qR) + c_t q(1-R - p(k-\beta R)) + \]
\[
- T_0 q \left( R(1-p\beta) - \frac{\alpha(1+i)}{N}(1-\beta) \right) - q \alpha (1-\beta) \left( \frac{(D_{t-1} + E - T^n)(1+i)}{N} \right)
\]

and, again, it corresponds to the equation of a straight line with intercept
\[
h_1 = C_{t-1} (1-qp\beta) + (1-q)S_{t-1}R + Y(1+qR) - T_0 q \left( R(1-p\beta) - \frac{\alpha(1+i)}{N}(1-\beta) \right) - q \alpha (1-\beta) \left( \frac{(D_{t-1} + E - T^n)(1+i)}{N} \right)
\]
and slope
\[
l_2 = q(1-R - p(k-\beta R)). \]
Finally, \(E_t[W_{t+1}]\) for Scenario 3 can be written as:

(A.13) \[ E_t[W_{t+1}] = c_{t-1} (1-qpk) + (1-q)S_{t-1}R + Y(1+qR) + \]
\[
c_t q \left( 1-R - p(k-R) \right) - T_t q (R - pR)
\]
and the intercept is
\[
h_3 = [C_{t-1}(1-qpk) + (1-q)S_{t-1}R + Y(1+qR) - T_t q (R - pR)]
\]
while the slope is
\[
l_3 = q(1-R - p(k-R)).
\]

As can be seen, the three intercepts depend not only on \(C_{t-1}, T_n\) and the amount of the others’ contributions, but also on the unknown \(\alpha\); by comparing them, one can see that three situations are feasible: either \(h_1 > h_2\) or \(h_1 < h_2\)\(^{17}\), either \(h_1 > h_3\) or \(h_1 < h_3\)\(^{18}\), and

\(^{17}\) If \(C_{t-1} < \frac{T_0}{k} \left( R - \frac{\alpha(1+i)}{N} \right) + \frac{\alpha(1+i)}{Nk} (D_{t-1} + E)\).

\(^{18}\) If \(C_{t-1} < \frac{T_0}{k} \left( R - \frac{\alpha(1+i)}{N} \right) + \frac{\alpha(1+i)}{Nk} (D_{t-1} + E - (1-\beta) \sum_{j=1, j \neq i}^N T_j)\).
either $h_2 > h_3$ or $h_3 < h_2$. On the contrary, the three slopes depend on parameters only. By comparing them, it is straightforward to see that $l_3 > l_2$ and $l_2 > l_1$, but $l_1 > l_2$ if and only if $k > \beta R$, which depends on the subjective weight $\beta$. An example is given in Figure A.1, where $h_2 > h_3 > h_1$ and $l_3 > l_1 > l_2$.

Although there is no unique solution, an intuitive strategy would be to save as much as possible (accounting for $h$) until the second to last round, and then to consume the whole endowment in the last round, thus avoiding penalties and obtaining the maximum amount of interests to spend. However, the experiment comprises important sources of uncertainty: simultaneous choices with an unknown ending. Moreover, the unknown reductions in debt make the comparison with the cost of a penalty impossible. In fact, this amount depends on the choices of the other subjects, implying that the exact optimal allocations from round 10 to the end of the experiment cannot be found without allowing for full coordination between the participants.

Figure A.1. Expected value of $W_{it+1}$ for three values of savings, S1, S2, and S3 (example).

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Figure A.2. Strategic analysis, subject 1's outcomes, two rounds, \((t, t+1)\).
References


Woo, J., Kumar, M. S. (2015), "Public debt and growth", *Economica*, 82(328), 705-739.