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We consider the tax progressivity decision of a rent-maximizing government when voters' perceptions of the tax price of public goods are biased by cognitive anomalies (i.e., fiscal illusion), and the electorate opts for re-appointing or for dismissing the incumbent according to a retrospective voting logic. Given electoral and constitutional constraints, we show that the design of the tax system can be sensibly affected by fiscal illusion within the population of voters. Specifically, we find that (i) the tax system is more (less) progressive when taxes and public expenditures are perceived less (more), and (ii) an increase in the median voter's income may positively or negatively affect tax progressivity depending on the nature (pessimistic or optimistic) of fiscal illusion. The impact of fiscal illusion on tax progressivity is validated by econometric analysis.

1   Introduction

According to the recent "Focus on Inequality and Growth" (OECD 2014), disposable income inequality has been rising significantly over the past three decades in a vast majority of OECD countries. Addressing this trend has moved to the top of the policy agenda in many countries, and, not surprisingly, most of the attention has been devoted to the identification of its major determinants.

In this paper, we offer a formal framework by which fiscal illusion is shown to be one of the determinants of the redistribution induced by progressive fiscal systems as designed by a self-interested policy maker, who is assumed to maximize the rent extracted from total taxes by compensating the sole 50%+1 of voters (through public goods/services and selective transfers).[1] This result is particularly relevant as, in our view, the decline of fiscal illusion in the last decades (e.g., Mourao 2008) may have significantly concurred to the reduction of the progressivity of fiscal systems, and so, to the rise of disposable income inequality.

Standard models of voting on redistribution are based on the median voter theorem (e.g., Roberts 1977, Meltzer and Richard 1981). The baseline expectation of this body of literature is that increasing skewness of the income distribution increases redistributive government intervention. However, a considerable body of empirical literature on this topic has produced inconclusive findings (Acemoglu et al. 2015, Bredemeier 2014).

A second generation of median voter models has incorporated many features of real political systems, such as differences in political institutions, electoral systems, constraints on the use of non-linear tax systems, and lobbying (Timmons 2010). According to Persson and Tabellini (2002), the optimal design of redistributive policies results from the design of political institutions, independently of the income distribution. Winer and Hettich (2008) consider an extension of the median voter approach to a non-linear tax-system and point out that the variance of income also affects the equilibrium size of government, because with a higher variance more redistribution is demanded by the median voter whose income is below the average (Cukierman and Meltzer 1991). Benabou (2000) and Stiglitz (2012) also note that standard predictions depend on the strong assumption that the rich have no more political influence than the poor.

In this paper we contribute to this second generation of models by relaxing the initial assumption in Meltzer and Richard's (1981, p. 981) seminal paper: "voters do not suffer from fiscal illusion", that is, we account for voters' misperception of the magnitude of taxes and public expenditure programs. The departure from (standard) rational decision-making is even more important in the field of political economy as optimal policies are inevitably driven by voters decisions, whose incentives to gain information and learn mechanisms are much weaker and more indirect than in the marketplace (Schnellenbach and Schubert 2015).[2] Not surprisingly, Akerlof and Dickens (1982) argue that cognitive anomalies in voter behavior are important determinants that not only justify but also determine the structure of public policies.

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[1] Notice that our formalization of the relationship between fiscal illusion and tax progressivity is independent from the old Wagnerian conjecture by which fiscal illusion increases public expenditure and, eventually, redistribution (e.g., Oates, 1991; Dollery and Worthington, 1996; Gemmell et al., 1999; Gemmell et al., 2003).

[2] For a survey of this sub-field of behavioral economics, see also McCaffery and Baron (2006), Congdon et al. (2009), Slemrod (2010), Alm (2010), Dell'Anno and De Rosa (2013), Bisin et al. (2015), Ortoleva and Snowberg (2015), Dell'Anno and Martinez-Vazquez (2019).

Three main simplifications characterize our model of political equilibrium: (i) the *retrospective voting hypothesis* suggests that voters are indifferent to political programs presented by both the incumbent and the opponent, for no value is attributed to proposed platforms and/or ideological preferences of political parties (Persson and Tabellini 2002). The only reason not to re-appoint an incumbent is to punish the government for a (perceived) negative net-benefit from government's activities, independently from promises during election campaigns (i.e., no electoral competition); (ii) the government has *accurate knowledge* of both voters' gross income and voters' misperception of taxes and public expenditure programs (e.g., through opinion polls). To maintain analytical tractability, (iii) we also assume that politicians *cannot manipulate* voters' cognitive anomalies proactively.[3]

Our results yield important implications for understanding the relationship between cognitive processes underlying voting behavior and tax progressivity. First, we show that, in the presence of a non-linear progressive (income) tax system, whose tax revenues are (partially) used to finance public goods/services and selective transfers — e.g., pork-barrel spending (Lizzeri and Persico 2001, Maskin and Tirole 2014); special groups transfers (Coate and Morris 2005) — the progressivity of the tax system, due to fiscal illusion, can be (ab)used by the policy maker to enhance the rent extracted from the population while maintaining standard vertical and horizontal equity constraints. Specifically, fiscal illusion is shown to affect the 'profitability' of redistributive policies in the sense that, the less (more) voters perceive taxes (and/or the more voters perceive public expenditure), the more (less) progressive the tax system is expected to be. This result is basically driven by the two following motivations: (i) if fiscal illusion increases (decreases), then less (more) public goods/services and selective transfers are required to compensate ('buy the vote of') the 50%+1 of the electorate, that is, taxation becomes more (less) profitable at the margin within the decisive set of voters (i.e., 50%+1); (ii) if taxation becomes more (less) profitable at the margin, then the policy maker will maximize its rent by increasing (decreasing) taxation on the set of richest voters with relatively low perception of the tax burden. In our view, this result is immediately relevant for policy purposes as it emphasizes the causality between decreasing fiscal illusion, public budget cuts, and diminishing tax progressivity, which may be of help for a better understanding of recent increasing trends in disposable income inequality (Piketty and Saez 2006, Isabelle et al. 2012, OECD 2015).

Second, we propose a revision of Meltzer and Richard's (1981) standard result by which an increase in the median voter's income is expected to reduce redistribution. More specifically, we show that this prediction holds if and only if the median voter is characterized by pessimistic illusion (i.e., taxes are perceived more than public spending), in the sense that s/he perceives taxes more than actual ones, and/or public expenditure less than actual one. Vice versa, if fiscal illusion is optimistic (i.e., taxes are perceived less than public spending), then an increase in the median voter income is expected to strengthen, and not weaken, progressivity. The intuition is the following. When the median voter — precisely, the set of decisive voters in our model — perceives public expenditures more than taxes, a positive income variation generates an increase in taxes which is less than compensated through public spending to preserve the political support of this voter. Hence, a positive income variation in the decisive set of voters makes the tax-benefit system more profitable at the margin for the incumbent who, as such, increases taxes levied on the richest voters in the decisive set,

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[3] At the cost of reduced formal tractability, fiscal misperceptions may be assumed to be endogenous (i.e., depending upon tax burden, degree of progressiveness, level of inequality, cultural standards and values, etc.). This would enrich our model but it would inevitably embrace several informative and psychological aspects which may obscure our focus on fiscal illusion, independently from manipulation possibilities.

or, equivalently, maximizes his rent by making the tax system more progressive.

This paper is organized as follows. Section 2 provides a brief overview on the related literature. Notations and basic model assumptions on the behavior of voters and the government are presented in Section 3. In Section 4, the main results of our model are discussed. The empirical analysis supporting our theoretical findings is discussed in Section 5. Section 6 summarizes and discusses main findings.

2   Related Literature

In our model the possibility of misperception of taxes and public expenditures is embedded in a voting model where voters behave according to the retrospective voting logic, whereas the incumbent is allowed to use both selective public transfers and public goods/services to be re-appointed. In what follows, we briefly recall the main literature on each of the three major topics characterizing our analysis.

2.1   The fiscal illusion hypothesis

The fact that voters may suffer from fiscal illusion has been debated for more than two centuries. The first systematic analysis of fiscal illusion has been developed by Puviani (1903). In his pioneering work, Puviani focused on the possible types of illusion. This topic was largely unexplored until Buchanan (1960, 1967) restored attention to this hypothesis.[4]

There are several definitions of fiscal illusion. Here, we follow the definition provided by Oates (1988, p. 65); accordingly, fiscal illusion refers to "the notion that systematic misperception of key fiscal parameters may significantly distort fiscal choices by the electorate".

In line with Puviani's (1903) original classification of fiscal illusion, we distinguish between pessimistic and optimistic fiscal illusion. In the case of optimistic illusion, citizens perceive the tax price of public expenditure as lower than the actual one. Conversely, when fiscal illusion is of the pessimistic kind, the tax price is perceived as higher than the real one. That is, optimistic illusion is favorable to incumbents because voters perceive the cost of public programs to be lower than the actual cost, and vice versa.

In the following Section, we show that the nature of fiscal illusion — optimistic or pessimistic — strongly affects progressive taxation as decided by a rent-maximizing incumbent. In this sense, we argue that fiscal illusion provides an alternative way of including institutional factors (distributive value judgments, altruism, risk aversion, diminishing marginal utility of income, political stability, human capital accumulation) among the determinants of redistributive policies.

2.2   Retrospective voting

Retrospective voting models are based on the absence of electoral competition, for each voter is

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[4] In a roundabout way, this hypothesis shares a background with more recent empirical studies of voting behavior by assuming cognitive biases e.g., Mullainathan and Washington 2009, Shue and Luttmer 2009. For a review, see Chong and Druckman (2007). It is worthwhile pointing out as relatively scarce research has analyzed causes, consequences and behavioral bases of (mis)perception of tax rate (e.g., Enrick 1963, Lewis 1978, Slemrod 2006, Gideon 2017). In particular, Gideon (2017, p. 97) states as "despite its theoretical and practical importance, little attempt has been made to directly measure and systematically analyze income tax rate perceptions".

supposed to vote either for or against an incumbent (e.g., Barro 1973, Ferejohn 1986, Persson et al. 1997) by taking into account the sole (perceived) outputs of government actions, independently from political promises and alternative political parties. In a sense, voting decisions are assumed to be driven by the incumbent's past performances only, in a political scenario where, by virtue of backward logic, no value is attached to proposed platforms marked as not credible.[5]

The retrospective voting model is enriched by the presence of fiscal illusion, which offers a more realistic representation of the public choice mechanism underlying the rent-maximizing design of the tax-benefit system. As mentioned above, we focus on the degree of fiscal illusion as exogenous parameter characterizing each voter; as such, the possibility of strategic manipulation of voters' misperceptions is disregarded despite its practical relevance.

Our theoretical framework differs from standard models in several ways: as far as tax progressivity is concerned, we consider a population of heterogeneous voters (in terms of both income and fiscal illusion), and not a representative voter (Barro 1973). With respect to Ferejohn's (1986) extension to a population of heterogeneous voters, we focus on the rent-maximizing decision of the incumbent, and not on the utility maximizing choice of voters having access to private information on their type. Evidently, since voter's type is defined in terms of fiscal illusion, taking the latter as private information would contradict the fiscal illusion hypothesis by definition. Instead, it is natural to expect that "policy-makers have access to much better information on the relative merits and precise consequences of alternative policies than the population at large" (Persson et al. 1997). Hence, to keep the model simple, and to concentrate on the implications of fiscal illusion independently from the size of the information gap, we assume that political parties can infer voter's (mis)perception of the tax price through 'microtargeting' techniques (Jacobs and Shapiro 2005), e.g., by collecting personal data on educational attainments, employment status, political ideology, etc.

Formally, we consider a non-repeated sequential game equilibrium in which the tax-benefit system is settled by the incumbent at the first stage, while voters, given their (observable) reservation utility, vote for re-appointing or dismissing the incumbent at the second stage. By backward induction, the design of the tax-benefit system is determined in such a way as to maximize the rent — tax revenues minus public spending (public goods/services and selective transfers) — extracted from the population.

In contrast with the original approach (Persson and Tabellini 2002), we rule out the possibility of the incumbent's escaping strategy, i.e. a 100% tax rate with zero public spending and no re-appointment. Instead, to better focus on the implications of fiscal illusion on the design of public policies, we simplify the basic framework by assuming that, if a non-negative rent can be extracted, then reelection is generally preferred by the incumbent.[6]

2.3 Selective public transfers

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[5] As observed by Ferejohn (1986, p.6), "assuming that voters would believe any proposed platform, a challenger will virtually always be able to propose a platform that will defeat the incumbent. But if the incumbent knows that he will lose his re-election bid, he might as well simply pursue his own private interest while in office rather than doing what he promised during the campaign (or doing whatever he did during his previous term); he will be turned out at the next election anyway. Clearly, in this case, the voters have no reason to take challenger platforms as anything other than pure rhetoric ...".

[6] This simplification does not alter our main findings: if the standard sequential game à la Persson and Tabellini (2002) were implemented, then the impact of fiscal illusion on tax progressivity would remain the same, but the optimal size of the rent would be independent from fiscal illusion.

The government is assumed to be self-interested rather than social welfare maximizing even if, by virtue of constitutional constraints, standard value judgments in terms of horizontal (i.e., equal taxes for equal income endowments) and vertical equity (i.e., greater taxes for richer units) are granted.

We assume that income taxes collected by the incumbent can be used to fund both *selective public transfers* and public goods/services. As compared to public goods/services, selective public transfers are usually more expensive but, in a retrospective voting logic, can be exploited to benefit the 50%+1 of voters only.

The relevance of selective transfers in real public expenditure programs has been widely recognized and explored in the existing literature. As observed by Coate and Morris (2005, p. 1210), "[a] significant portion of government activity is devoted to the transfer of resources between citizens. Some of these transfers, such as those to the poor, seem to be consistent with traditional social welfare objectives. Others are directed to so-called special-interest groups, [...] and seem harder to justify on normative grounds." Mainly, a self-interested policy maker chooses *special-interest groups transfers* for two main reasons: (i) interest groups may be able to enhance politicians' chances of reelection by providing campaign contributions or political support; (ii) interest groups may improve politicians' financial well-being, e.g., by providing bribes, future employment opportunities etc.

In the same spirit of special-interest groups transfers, an extensive literature has been focusing on the impact of *pork-barrel spending*, i.e., "projects that are financed by broad-based taxation but provide benefits that are geographically limited in scope" (Grossman and Helpman 2005).

Altogether, our modeling framework is "hybrid": standard objectives of a social welfare maximizing policy maker are accounted for through horizontal and vertical equity constraints in the design of the tax system (e.g., by constitutional norms); however, in line with standard models of political economy, the policy maker is assumed to manipulate (partially) public policies in such a way as to search for reelection. More specifically, as shown in what follows, the rent-maximizing policy maker pursues this target especially through selective transfers, since the use of the tax system for reelection is much more expensive in the presence of constitutional constraints.

3   The Model

3.1   Voters

Voters misperceive both taxes and public expenditures, that is, false beliefs may characterize each individual. Two major aspects must be highlighted. First, individuals are assumed not only imperfectly informed but also cognitively biased. Second, even if fiscal illusion is usually circumscribed to taxation only (e.g., Schneider and Pommerehne 1980), here we extend this hypothesis by considering the possibility of misperception of public expenditures as well; as observed in Musgrave (1981), this possibility cannot be disregarded since "the benefits of public programs could be underestimated due to their permanent nature, as the sun in the sky".

We define the *i*-th voter utility as $u_i = y_i - \delta_i t_i + \beta_i g_i$, where $\delta_i \in \Re_+$ represents voter awareness of the tax burden with $i := 1, \ldots, n$; $t_i \in \Re_+$ is the tax bill to be paid by the *i*-th voter, which depends on gross income, $y_i \geq 1 \; \forall \; i$. Voter awareness of public benefits (public goods/services and selective transfers) is measured by $\beta_i \in \Re_+$, whereas $g_i \in \Re_+$ is the money value of public benefits received by the *i*-th voter.

For our purposes, the *i*-th voter acts in an instrumentally rational way as s/he votes for the incumbent if and only if s/he perceives that s/he pays no more taxes than benefits received from public services and transfers, i.e., $\delta_i t_i \leq \beta_i g_i$, so that the *i*-th reservation utility is $u_i \geq y_i$.

Assuming cognitive bias in fiscal perception implies the following: (a) δ_i is greater or less than 1 whether taxes are over- or under-valued by voters respectively, and (b) β_i is greater or less than 1 whether benefits from the public expenditure program are over- or under-valued by voters respectively. Fiscal illusion is absent if and only if $\delta_i = \beta_i = 1$. As such, individuals are assumed to differ from each other with respect to their exogenous[7] gross income (y_i) and tax-benefit awareness (δ_i/β_i), which is a personal characteristic determined by (i) voter's attributes (such as demographic and ethnic group, cultural background, or cognitive abilities), and (ii) voter's attitudes towards the government (eventually biased by political ideology). For our purposes, no *a priori* assumption is made on the correlation between income and tax-benefit awareness. In what follows, we define $\theta_i = \delta_i/\beta_i$ as the *perceived tax price* of public spending for the *i*-th voter.

A distinction is made among voters according to the misperception of the tax price. Specifically, a voter is said to be

1. "optimistic", whether s/he perceives the tax price of public spending as lower than the actual one (i.e., $\delta_i/\beta_i \equiv \theta_i < \theta^{actual} = 1$). Accordingly, the voter's misperception of taxes is lower than misperception of public benefits ($\delta_i < \beta_i$). Notably, this result does not imply that an optimistic voter necessarily under-perceives taxes. For example, a pessimistic taxpayer who perceives higher tax burden than the actual one ($\delta_i > 1$) to be defined as an optimistic voter is sufficient to have a grade of over-perception (i.e., an optimistic illusion) of the benefits of public spending higher than the pessimistic view on taxation side ($1 < \delta_i < \beta_i$);

2. "pessimistic", whether s/he perceives the tax price of public spending as higher than the actual one (i.e., $\theta_i > \theta^{actual} = 1$). For this voter, misperception of taxes is higher than misperception of public spending ($\delta_i > \beta_i$). Also in this case, an optimistic taxpayer, who perceives lower tax burden than the actual one ($\delta_i < 1$) may be a pessimistic voter if his/her under-perception (i.e., pessimistic illusion) of the benefits from public expenditure is more than compensated by his/her under-perception of tax burden (i.e., $1 < \beta_i < \delta_i$);

3. "realistic", whether s/he perceives the tax price as equal to the actual one (i.e., $\theta_i = \theta^{actual} = 1$). It implies neutral fiscal perceptions which, remarkably, can be determined by the absence of voter misperception $\delta_i = \beta_i = 1$ (i.e., no illusion) or, also, equal intensity of misperceptions, i.e., $\delta_i = \beta_i$ (i.e., "compensating" illusion).

3.2 Government

The incumbent is assumed to maximize the rent extracted from total taxes (or *political income* according to Barro (1973)), $R = T - G$ where T, G, and R indicate, respectively, the total amount of tax revenues, public expenditures, and the rent. Specifically, the incumbent is willing to be

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[7] Notably, at the cost of a lower analytical tractability, a departure from the basic model might be proposed by assuming that individual perceptions of the tax burden and benefits influence incentives to effort in the labor market; as such, the rent-maximizing policy maker would be required to account for additional (incentive) constraints which may affect the size of the rent extraction.

re-appointed if, and only if, the rent is non-negative. In this basic formulation the positive rent, R, is drawn from the public budget surplus, if any; however, this is far from being decisive in our analysis since positive rent extraction might be conceived in the presence of public budget deficit as well.[8]

We assume a non-linear income tax schedule with an increasing marginal tax rate[9] and non-negative taxes. Formally, $T = \alpha \sum_{i=1}^{n} y_i^\varepsilon$ with $t_i = \alpha y_i^\varepsilon$; $\alpha > 0$ indicates a constant tax rate in a proportional tax system, while $\varepsilon > 0$ determines the progressivity/regressivity of the tax system. To the extent that for any tax system to be plausible income taxes that cannot be greater than income itself, α and ε are constrained in such a way as to ensure $\alpha y_i^\varepsilon \leq y_i$ $\forall$ $i = 1, \ldots n$.

The public expenditure program (G) consists of a mix of (i) selective benefits, $\tilde{g}_i \in \mathfrak{R}_+$ $\forall$ $i := 1, \ldots n$, and (ii) non-excludable goods/services, $\bar{g} \in \mathfrak{R}_+$. To keep the model simple, the benefits from public goods/services (universally granted to the entire population) are assumed to be the same for each individual. However, the incumbent can freely select the beneficiaries, either at the individual or at the group level, of selective public transfers, e.g., special interest transfers (Coate and Morris 1995), pork-barrel spending (Lizzeri and Persico 2001); specifically, $\bar{g}$ and $\tilde{g}_i$ are assumed to be perfect substitutes and additively separable with $(\bar{g} + \tilde{g}_i)$ indicating the money value of the public expenditure program for the i-th individual.

The overall cost of the public expenditure program is obtained by accounting for both public goods/services and selective transfers. Most importantly, to the extent that non-excludable goods/services are involved, we assume $G = \bar{g} n^\gamma + \sum_{i=1}^{n} \tilde{g}_i$ where $(1 - \gamma)$ measures the degree of *Samuelsonian publicness* of government's output (Bergstrom and Goodman 1973, Gemmell et al. 2002) with $\gamma = 0$ minimizing the cost of the public service due to the total absence of rivalry (i.e. pure public good).

The incumbent is assumed to be perfectly informed on perceived tax prices (θ_i) and incomes (y_i). As such, recalling the reservation utility of each voter from the previous Section, it must be the case that the i-th voter supports the incumbent if and only if $\delta_i \alpha y_i^\varepsilon \leq \beta_i (\bar{g} + \tilde{g}_i)$ or, equivalently,

$$\theta_i y_i^\varepsilon \leq \frac{\bar{g} + \tilde{g}_i}{\alpha} \tag{1}$$

Evidently, for the incumbent to be re-appointed, the latter is supposed to maximize the rent (R) while obtaining, within a majoritarian system, the vote of 50%+1 voters at least.

Altogether, the maximization program of the incumbent can be formalized as follows.

$$\max_{\alpha,\varepsilon,\bar{g},\tilde{g}_i} \quad R = T - G \quad s.t. \begin{cases} I) & T \geq G, \\ II) & T = \alpha \sum_{i=1}^{n} y_i^\varepsilon; \alpha, \varepsilon > 0, \\ III) & G = \bar{g} n^\gamma + \sum_{i=1}^{n} \tilde{g}_i; \gamma[0,1], \\ IV) & \alpha y_i^\varepsilon \leq y_i \ \forall \, i, \\ V) & \theta_i y_i^\varepsilon \leq \frac{\bar{g} + \tilde{g}_i}{\alpha} \ \forall \ i \in D, \#(D) \geq (n/2 + 1) \end{cases} \tag{2}$$

where D and $\#(D)$ indicate, respectively, the set and the number of voters supporting the

incumbent.

Constraints from (I) to (V) exclude implausible results; indeed, it is natural to think that (I) the policy maker is not interested in re-appointment in case of a negative rent, (II) the tax system must be designed in such a way as to satisfy horizontal and vertical equity constraints, (III) real public expenditure programs include both selective and non-selective benefits, (IV) income taxes cannot be 'predatory'. Finally, constraint (V) characterizes our model, in that voters are assumed to support the incumbent according to the retrospective voting logic.

4   Rent-Maximization

In this Section, we characterize properties and implications of the interior solution to the maximization program in (2).

4.1   Median voter group and optimal public spending

To maximize his/her rent, the incumbent is required to 'buy' the political consensus of 50%+1 voters while minimizing the cost of compensation for their political support. According to condition (1), the incumbent is expected to buy voters (votes) with low income (y) and/or low perceived tax price (θ). Precisely, let $\alpha\theta_i y_i^\varepsilon$ be the compensation required by the i-th voter to vote for the incumbent (hereafter, *voter-price*). Given the increasingly ordered voter-price vector, $h(\varepsilon) := \{\alpha\theta_1 y_1^\varepsilon, \ldots, \alpha\theta_n y_n^\varepsilon\}$, the incumbent maximizes its rent when the sole 50%+1 voters with the lowest voter-price in $h(\varepsilon)$ are fully compensated through public goods/services and selective transfers. As such, it must be the case that the rent-maximizing mix of public goods/services and selective transfers is defined according to the following "tri-partition" of the electorate.

Proposition 1   *(Tri-partition of the electorate)*
Given a population of $n \geq 3$ voters, let $i = m$ indicate the median voter in the voter-price vector $h(\varepsilon) := \{\alpha\theta_1 y_1^\varepsilon, \ldots, \alpha\theta_n y_n^\varepsilon\}$. It must be the case that an exhaustive and complete tri-partition of the population exists such that: $(i.)$ D_1 is the set of voters such that $i \in [1, \ldots, d]$ in $h(\varepsilon)$ with $d \leq m$, which is compensated for (perceived) taxes through public goods/services only, with $\bar{g}^* = \alpha\theta_d y_d^\varepsilon$; $(ii.)$ D_2 (hereafter, median voter group) is the set of voters such that $i \in [d+1, m]$ in $h(\varepsilon)$, which is compensated for (perceived) taxes through both public goods/services, with $\bar{g}^* = \alpha\theta_d y_d^\varepsilon$, and selective public transfers, with $\tilde{g}_i^* = \alpha(\theta_i y_i^\varepsilon - \theta_d y_d^\varepsilon)$; $(iii.)$ D_3 is the set of voters such that $i \in [m+1, n]$, which is partially, not fully, compensated for (perceived) taxes through public goods/services only ($\bar{g}^* = \alpha\theta_d y_d^\varepsilon$).

[Proof of Proposition 1: see appendix]

Proposition 1 maintains that if public expenditures are optimally defined in such a way as to minimize the cost of compensating the majority of the electorate, then a tri-partition of the population is obtained, where each subgroup can be optimally characterized with respect to the composition of the public expenditure program. Most importantly, to the extent that both public goods/services and selective transfers are simultaneously permitted, the median voter consists of a "group", and not a single individual, because the public expenditure program is (ab)used by the

incumbent to gain the political consensus of the majority of voters independently from the design of the tax system. In other words, in the presence of vertical and equity constraints (reducing the degree of freedom on the design of the tax system), the (ab)use of selective transfers (e.g., special groups transfers) turns to be a cheaper way to compensate the electorate in the attempt to be re-appointed.

Moreover, as concerns the (endogenous) size of the three groups in Proposition 1, it is worth observing that the value of $d \leq m$ depends uniquely on the degree of Samuelsonian publicness of government's output $(1 - \gamma)$; specifically, the policy maker is more willing to use public goods/services to compensate decisive voters when a high degree of non-excludability characterizes public expenditures (see proof 1 in the Appendix).[10]

Three major remarks can be gathered from Proposition 1.

Remark 1   *(Median voter group)*
If the incumbent maximizes its rent, then the group of decisive voters, i.e. the median voter group, can be identified with respect to the distribution of voter-prices. Most importantly, this is the only group benefitting of selective public transfers, whereas public goods/services are granted to the entire population by definition.

From Proposition 1, given the cost of the entire public expenditure program, $G = \bar{g} n^\gamma + \sum_{i=1}^{n} \tilde{g}_i$, as far as selective public transfers are paid to the sole voters in the median voter group — which are also benefitting of public goods/services as the rest of the electorate — if the maximal rent is extracted, then the cost of the public expenditure program (G) is equivalent to the cost of compensating the median voter group $(G_{D_2}^*)$; formally,

$$G^* = G_{D_2}^* = \sum_{i=d+1}^{m} (\bar{g}^* + \tilde{g}_i^*) = \alpha \sum_{i=d+1}^{m} \theta_i y_i^\varepsilon \qquad (3)$$

Remarkably, the sole fiscal illusion among decisive voters (median group) affects the public expenditure program and, consequentially, the design of the tax system.

Remark 2   *(Perceived redistribution)*
Given the tri-partition in Proposition 1, individuals in the set D_1 perceive positive net benefits from the tax-benefit system, while individuals in the set D_3 perceive negative net benefits.

The probability of benefitting from public sector services is generally higher when the voter is characterized by a relatively low income and/or highly optimistic illusion (i.e. lower θ). The first part of this statement is largely supported in the existing literature, while the second part is not. As Sir Francis Bacon wrote in the 1597, one may expect that "Ipsa scientia potestas est" (Knowledge itself is power), that is, voters with superior knowledge have more political power and, in turn, secure more from redistributive policies. In our model this result holds if the population is characterized by pessimistic illusion. Conversely, if the electorate consists of optimistic voters, then redistribution through the public sector (tax-benefit system) is expected to benefit individuals with relatively high

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[10] In the tri-partition above, two special cases can occur. First, if the degree of publicness γ is sufficiently large, the government is willing to use lump sum transfers only (i.e. $\bar{g} = 0$), then the tri-partition becomes a bi-partition because all voters supporting the incumbent are exclusively compensated through personalized lump sum transfers. However, as shown in the appendix (see proof 1), for sufficiently large n, we can exclude this unrealistic state of the world. Second, if $\gamma = 0$ (i.e. pure public goods), then the government is willing to use $\bar{g}$ only.

optimistic illusion and, hence, those who are not well-informed.

Remark 3   *(Effective redistribution)*
Given the tri-partition in Proposition 1, any individual characterized by fiscal illusion of the pessimistic kind within the set D_1 or D_2 obtains positive net benefits from the tax-benefit system.

When considering effective (not perceived) redistribution, a voter is a (positive) net beneficiary of the tax-benefit system if s/he is both compensated by the incumbent and of the pessimistic kind; not surprisingly, the possibility of the incumbent to extract a higher rent is limited by pessimistic illusion.

4.2   Rent-maximizing tax progressivity

Given the optimal composition of the public expenditure program from Proposition 1, the maximization program in (2) can be equivalently reformulated as

$$\max_{\alpha, \varepsilon} \quad R = \alpha \left(\sum_{i=1}^{n} y_i^{\varepsilon} - \sum_{i=d+1}^{m} \theta_i y_i^{\varepsilon} \right) \quad s.t. \begin{cases} R \geq 0, \\ \alpha y_i^{\varepsilon} \leq y_i \ \forall \ i \end{cases} \tag{4}$$

where $\partial R / \partial \alpha \geq 0 \ \forall \ \alpha$. To the extent that constraint (IV) in (2) must hold true at the optimum for each voter, it follows that (i) $\alpha^* = [Min\{y\}]^{1-\varepsilon^*}$ when $\varepsilon^* < 1$,(ii) $\alpha^* = 1$ when $\varepsilon^* = 1$, and (iii) $\alpha^* = [Max\{y\}]^{1-\varepsilon^*}$ when $\varepsilon^* > 1$, i.e., if the public expenditure program is optimally chosen, then α^* is implicitly defined by (i) the income distribution and (ii) the progressivity parameter ε^*.

In addition, it is worth observing that the fiscal illusion parameter, θ, of "each" voter in the median voter group, D_2, affects the design of the tax system, whereas in the existing literature it is usually the case that the median voter is the "only" voter affecting the (optimal) rate of tax progressivity. This departure from standard models is an immediate implication of the hybrid framework we opted for (rent maximization under constitutional constraints): voters are usually supposed to vote on the size of redistribution (e.g., Meltzer and Richards 1981), whereas in our model individuals vote for, or against, the incumbent who, in turn, chooses the size of redistribution in such a ways as to maximize the rent in the presence of reelection constraints.

As concerns the maximization program in (4), we first consider the benchmark case with no fiscal illusion.

If $\delta_i = \beta_i = \theta_i = 1 \ \forall \ i$, then (i) the incumbent optimally chooses the 100% proportional tax system[11], i.e., $\varepsilon^* = 1$ and $\alpha^* = 1$, and (ii) the incumbent always aims to be reelected because the rent, *R*, is non-negative by construction. Basically, as far as selective public transfers can be used to compensate decisive voters according to their voter-price, in the absence of fiscal illusion, the incumbent is expected to redistribute resources through the public expenditure program only, while collecting as many resources as possible on the tax side, i.e. there is no motivation for progressivity in the design of the tax system when the redistribution can be optimally pursued through public expenditures.

Apart from the benchmark case, a corner solution is obtained whenever, due to the distribution of the perceived tax price θ and income y, the increasingly ordered vector of voter-prices, $h(\varepsilon)$, is

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[11] Evidently, the 100% proportional tax is intended as a generic corner solution, which may be more realistically constrained by introducing a maximum tolerance parameter (e.g. Peacock and Wiseman 1961).

defined such that $\partial R / \partial \varepsilon > 0 \; \forall \; \varepsilon$. In that case, it can be shown that, due to the second constraint in (4), the maximal rent is obtained, once again, by imposing a 100% proportional tax system, while compensating the sole 50%+1 voters through the optimal composition of public spending. As such, if an interior solution does not exist, then fiscal illusion is not affecting the degree of progressivity of the tax system.

Alternatively, if an interior solution exists, then fiscal illusion does affect the optimal degree of tax progressivity. Specifically, from the first-order conditions, it can be shown that an interior solution exists when (i) the average perceived tax price in the median group is sufficiently greater than one (i.e., pessimistic illusion is dominant in the current society), and (ii) voters in the median voter group are relatively less pessimistic than in the rest of the population, and their incomes are sufficiently larger than in the rest of the population.[12]

Intuitively, the interior solution reflects a society characterized, on average, by pessimistic fiscal illusion where taxes are perceived more than public expenditures, and where richest voters are relatively less pessimistic than on average. Even non-interior solutions cannot be excluded on a priori grounds, one may agree that individuals are more inclined to over-perceive taxes as compared to public expenditures (pessimistic fiscal illusion), and that, major earners in the society might be less pessimistic due to greater human capital endowments stimulating more consciousness on the magnitude of key fiscal parameters.

Hence, provided that the profile of a society is such that an interior solution is obtained, if θ_i increases for some voter in the D_2 group (i.e., illusion of the pessimistic kind increases), then the compensation (in terms of public expenditures) demanded by the richer voters in the D_2 group increases, meaning that a less progressive tax system becomes rent maximizing. The following Proposition formalizes this aspect.

Proposition 2   *(Fiscal illusion and tax progressivity)*
If an interior solution exists, then tax progressivity is decreasing in $\theta_i \; \forall \; i \in D_2$.

[Proof of Proposition 2: see appendix]

Formally, if higher (lower) compensation (G) is required by voters in the median group as a consequence of higher (lower) perceived tax price, then preserving optimality requires that this variation be compensated. The incumbent catches up the equilibrium by softening (strengthening) the progressivity of the tax system because a lower (higher) ε reduces (increases) both T and G with the latter effect being the dominating one. This allows to restore equivalence between tax revenues and public expenditures at the margin.[13]

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[12] If an interior solution exists, then this must be (locally) unique for each $h(\varepsilon)$-ordering (proof omitted for the sake of brevity). Basically, it can be shown that, for each $h(\varepsilon)$-ordering, the first order condition cannot admit more than one zero, whereas two zeros are necessarily required to have multiple solution for each $h(\varepsilon)$-ordering. Global uniqueness, instead, can be shown to require additional conditions: (i) negligible discontinuities in the first order condition due to variations of ε altering the $h(\varepsilon)$-ordering, and (ii) not-so-negative correlation between income and pessimistic illusion.

[13] It is worth observing that this result reverses the causal relationship and the sign of the correlation between progressivity and pessimistic fiscal illusion proposed in the extant literature. While Buchanan (1967) argues that progressivity, *per se*, tends to create a feeling of excess tax burden and therefore causes pessimistic fiscal illusion, in our model, voter cognitive limitations increase pessimistic illusion so to provide (rent-maximizing) incentives for less progressive taxation.

Intuitively, if fiscal illusion becomes more pessimistic in the median voter group, then progressivity becomes less profitable, in that the political support of richer voters becomes relatively more expensive. A practical implication of this result is that if the electorate's mood towards the incumbent deteriorates, (e.g., pessimistic illusion in the median group increases due to increasing tax literacy or public sector transparency), then the rent extracted from the electorate diminishes, tax progressivity becomes less profitable, and more inequality is expected to be observed in the disposable income distribution.

In addition to the impact of the perceived tax price on the optimal degree of redistribution, the former also affects the rent extracted by the incumbent. At first, one might reasonably expect the rent to be increasing with illusion. However, this consideration would account uniquely for the *direct effect* of the perceived tax price: a lower $\theta_i \ \forall \ i \in D_2$ reduces the cost of compensating the i-th median voter (so the overall cost of compensating the set of decisive voters) which makes profitable to increase the size of the public sector. This is done by increasing the progressivity of the tax system (Proposition 2), which in turn lessens the rent (*indirect effect*), since public expenditures growth faster than taxes at the aggregate level. Remarkably, indirect and direct effects have opposite signs, so that the major rent which may be extracted as a result of a better mood is partially offset by enhancing tax progressivity.[14]

Proposition 3   *(Median income and tax progressivity)*
Any increase in the median voter's income reduces the progressivity of the tax system whether illusion is of the pessimistic kind, and vice versa.

[Proof of Proposition 3: see appendix]

Proposition 3 extends the standard result obtained by Meltzer and Richard (1981) in which an increase in the median voter's income reduces redistribution. In our framework, given the plurality of median voters, the previous result is confirmed if and only if voters in the median group are characterized by pessimistic illusion. In the presence of pessimistic illusion, an increase in the total income of the median group is expected to reduce the degree of progressivity because increasing tax revenues due to positive income variations must be over-compensated. In contrast, Meltzer and Richard's (1981) result does not hold when voters are characterized by neutral or optimistic illusion. Intuitively, if the income of a voter in the decisive set, D_2, characterized by fiscal illusion of the optimistic kind increases, then s/he pays more taxes which much be compensated in order to maintain the his/her political support. As far as s/he is optimistic, the cost compensation in terms of public expenditures is less than new tax revenues, that is, due to the positive income variation the tax-benefit system becomes more profitable at the margin for the incumbent. This being the case, the incumbent is expected to increase taxes levied on the richest voters in the decisive set, or, equivalently, to maximize his/her rent by making the tax system more progressive.

Basically, Proposition 3 extends the result of Meltzer and Richard (1981) because, in our model, the degree of tax progressivity is not the result of redistributive policies voted by utility-maximizing voters under the majority rule, but (ab)used by the incumbent to maximize the rent extracted from the public budget compatibly with re-appointment. This is crucial in that, in our model, the incumbent can

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[14]   The proof follows immediately by envelope logic.

extract the rent originating from fiscal illusion of the optimistic kind, whereas the same possibility is not applicable in standard voting models.

5 Empirical Analysis

In order to gauge whether the main theoretical implication of the model (Proposition 2) is consistent with empirical evidences, we perform an empirical analysis of the relationship between tax progressivity and fiscal illusion based on the data of 28 European countries for the period 1995-2008. Since we focus on European countries, the main assumption in the theoretical model is expected to hold true, that is, the incumbent is assumed to maximize its rent subject to electoral (i.e., democratic), financial (i.e., maintaining a balanced public budget), and constitutional (i.e., granting vertical and horizontal equity of the tax system) constraints. The time period has been selected according to the availability of data on fiscal illusion (i.e., Dell'Anno and Dollery 2014).

As a first empirical test, we calculate the pairwise correlation between the index of Fiscal Illusion and the proxy of tax progressivity. We find a positive correlation ($pwcorr$ = 0.213 with a p-value=0.000) that is indicative of a statistical significant relationship between these two variables.

As a second check, Figure 1 displays a graphical analysis of the bivariate relationship of Proposition 2.

Figure 1: Progressivity index of PIT Vs Fiscal Illusion Index
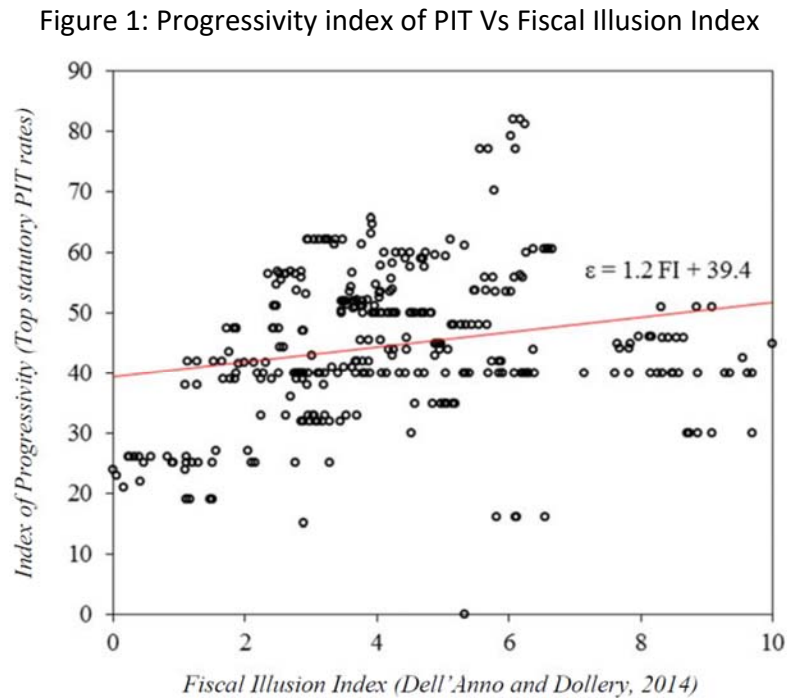
Finally, as a third test, we test Proposition 2 by which tax progressivity is expected to be decreasing w.r.t. $\theta_i \; \forall \; i \in D_2$" in the following (panel data) model:

$$\varepsilon_{it} = a_1 FI_{it} + a' X_{it}^S + e_{it}, \; i:= 1,\dots,28; t = 1995,\dots,2008 \qquad (5)$$

where the test consists of verifying if $a_1 > 0$.

5.1 Model Specification

We test Proposition 2 by checking the relationship between tax progressivity (ε) and Fiscal illusion (FI) controlling for a set of institutional, economic, and demographic variables.

5.1.1 The index of tax progressivity

As the measurement of tax progressivity concerns, following Duncan and Sabirianova Peter (2016), we can identify three groups of measures of tax progressivity: (1) effective inequality-based measures of progressivity; (2) structural progressivity measures, and (3) the top statutory Personal Income Tax (PIT) rate. Among these indicators, we opt for the top statutory PIT rate because, as Duncan and Sabirianova Peter (2016) point out, although this rate might be a misleading indicator of progressivity — due to the circumstance which proportional and progressive tax systems may have the same top statutory tax rate — it has sometimes been used in empirical cross-country research as a proxy variable for tax progressivity. Moreover, as Duncan and Sabirianova Peter (2008) estimate, a high (about 0.5) correlation exists between the top statutory tax rate and more complex global measures of structural progressivity.[15]

One of the main concerns when translating theoretical findings in a testable regression is that the available data are provided at the aggregate level (i.e., countries), whereas Proposition 2 refers to the unobservability of the tax price (θ) and tax progressivity (ε) for the median voter group. As such, we need assume that the median group's preferences for parameters θ can be inferred by observed economic policy. Specifically, following the median voter's approach,[16] we assume that the policy maker conforms its policy to preferences of the median voter group, so that observed macro-data on actual tax systems correspond to preferences the median voter group with respect to the tax price (θ) and tax progressivity (ε). That is, the empirical test of Proposition 2 is aimed at verifying if a negative relationship between the progressivity of the fiscal system (ε) and the perceived tax price (θ) holds: $\varepsilon/\theta < 0$ [1st assumption].

In conclusion, provided that: (1) the decisive median voter group is not defined uniquely by the personal income distribution but it also accounts for the (unobserved) perceived tax price (i.e. θ) and (2) if an interior solution exists — described by Proposition 2 —, this group of voters is composed by sufficiently rich voters, then the statutory marginal tax rate applicable to the top bracket of the

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[15] As the other two measures of tax progressivity concerns: the measures of effective income redistribution are not suitable for our analysis because they are usually calculated as difference between pre-tax income and post-tax income distribution (e.g. Reynolds and Smolensky 1977) where the post-tax income distribution also depends on public selective transfers (i.e. $\tilde{g}$ in the theoretical model). Given that theoretical Proposition 2, does notrefer to expenditure side but only to the progressivity of the tax system (ε), these measures are not suitable for our test. With reference to the structural progressivity measures — which capture changes in average and marginal rates along the income distribution — they require an exact level of gross income in which to estimate the difference between marginal and average tax rate. Unfortunately, on the one hand, the data on gross income distribution is difficult to gather in a comparable way at the cross-country level, and on the other hand, the level of gross income to measure structural progressivity is not constant in our median voter group. Accordingly, these measures of structural progressivity are not suitable for our empirical test.

[16] Implicitly, we are assuming that the median voter approach is effective in explaining the amount of redistribution. Although the empirical evidence attached to median theorem is far from being definitive (see Scervini 2012 for a survey of the empirical literature). This assumption has been recently validated by Groot and van der Linde (2016) who find, in a sample of countries (32 OECD countries over the period 1974-2012) similar to our dataset, that, on average, the decisive voter is effectively the median voter.

personal income tax schedule seems to be a reasonable choice to measure tax progressivity (ε).

5.1.2 The index of fiscal illusion

As a proxy of Fiscal Illusion, we use Dell'Anno and Dollery's (2014) index of Fiscal Illusion (FI) to account for (mis)perception of the tax revenue.

To use this proxy in our test, we have to deal with the problem of the unobservability of perceived tax price of public spending and on how, Dell'Anno and Dollery's (2014) index of fiscal illusion (FI), can be used to account for (mis)perception of tax revenue (δ). Specifically, the tax price of public spending in the median group is assumed to be affected by tax policies aimed at reducing the citizens' perceptions of real tax burden as measured by the Dell'Anno and Dollery's (2014) index of fiscal illusion.

In order to rely on this hypothesis, it is useful to explain how and what this index effectively measures.

Dell'Anno and Dollery's (2014) apply a Multiple Indicators Multiple Causes (MIMIC) model — which is a special case of the Structural Equation Modelling (SEM) — to estimate a latent (unobservable) variable. This latent variable measures the policy maker's effort to reduce taxpayers' perception of the tax burden. In Dell'Anno and Dollery (2004) the unobservable variable is related, on the one hand, to some potential (observable) causes — which account for policy maker's incentives to exploit fiscal illusion mechanisms[17] — and, on the other hand, to five (observable) indicators - which are potentially capable of reducing the taxpayers' perceptions of the tax burden (i.e. FI)[18].

As a consequence of this MIMIC model specification, a higher score of Dell'Anno and Dollery's (2014) index measures government's exploitation of policies aimed at distorting taxpayers' perceptions of the tax burden.

In view of that, we infer from the FI scores, the expected variation of median voters' misperception of the tax burden. In other words, a higher index value of FI indicates a larger use of pro-illusion fiscal policies and, as a consequence, higher FI is expected to lower perception of the real tax burden (δ) and, in turn, to reduce over-perception of the tax price ($\partial\delta/\partial FI < 0 \Rightarrow \partial\theta/\partial FI < 0$) for pessimistic or realistic voters ($\theta \geq 1$), and to increase under-perception of the tax price ($\partial\delta/\partial FI < 0 \Rightarrow \partial\theta/\partial FI > 0$) for optimistic voters ($\theta < 1$) [2nd assumption].

A further assumption is required to complete the causal chain behind the empirical test of Proposition 2. It deals with the unobservability of (mis)perception of public expenditure (β). In each period, a change in misperception of the tax burden is assumed to be no smaller than the misperception of tax benefits (i.e. $\Delta\delta_t/\Delta\beta_t < 0$). This parameter constraint is based on two considerations: (a) the existing literature on fiscal illusion has focused on tax policies rather than public expenditure programs;[19] (b) this parameter constraint allows to overcome the lack of data on

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[17] Dell'Anno and Dollery (2014) find that: (1) higher self-employment rates and (2) a higher tax burden incentive the policy maker to distort the perception of the tax burden; (3) higher percentage of people in the total population who have completed tertiary education disincentives Government to use pro-illusion tax policies because more educated people make these policies less effective to decrease perceived the tax burden.

[18] They find that (a) higher inflation rate (to account for fiscal drag); (b) higher public debt (to account for the Ricardian equivalence hypothesis); (c) lower ratio between indirect and direct tax revenues (to account for Mill's hypothesis); (d) higher implicit tax rate on labor and (e) withholding tax on labor income (to account for size and visibility of withholding tax on wages and salary income, respectively) by reducing the citizens' perceptions of real tax burden, increase, in turn, the fiscal illusion.

[19] The intuitive reason is that tax system reforms are faster and easier to put into operation than public expenditure programs.

misperception of public programs (β) that, at the best of our knowledge, are not available. In short, from the third assumption we infer that the tax price perceived by voters depends on taxpayers' perception of the tax burden.

In conclusion, the causal chain that links Dell'Anno and Dollery's FI index to tax progressivity is that, the higher the FI index, the lower is the expected voter's tax price of public spending (θ) and, in turn, this affects the optimal degree of tax progressivity (ε). The sign of the overall effect (a_1) is theoretically ambiguous because it depends on the nature of illusion (i.e. pessimistic or optimistic) in the median voter group. However, according to the theoretical model, if an interior solution is obtained, then the decisive group of voters (D_2) is expected to include more pessimistic voters than optimistic ones (i.e. the average perceived tax price in D_2 is greater than one), therefore, we expect a positive sign of correlation (a_1). Formally,

$$a_1 = \overbrace{\frac{\partial \varepsilon}{\partial \theta}}^{1^{st}Ass.} \overbrace{\frac{\partial \theta}{\partial FI}}^{2^{nd}Ass.} \quad with \quad \begin{cases} \frac{\partial \theta}{\partial FI} \leq 0 & \text{if } \theta \geq 1 \text{(pessimistic/realistic voter)}, \\ \frac{\partial \theta}{\partial FI} > 0 & \text{if } \theta < 1 \text{(optimistic voter).} \end{cases} \tag{6}$$

5.1.3 Control variables

To address the issue of potential omitted variable bias, we include a set of control variables (X^S) to capture a broad range of theoretically plausible determinants of tax progressivity in the hope of reducing this bias. Specifically, we include the lagged value of real GDP per capita (*Real GDPcap at time t-1)* as a proxy of economic development; income inequality before taxation and public transfers (i.e., Gini Index calculated on gross income: *Gini GrossInc*); two relevant variables on Government Budget (i.e. *Taxes on income as percentage of GDP - TaxIncome*; *Total general government expenditure as Percentage of GDP - GovExp*); two proxies which account for demographic features of the countries and of their labour market (*Population* and the number of persons aged 20 to 64 in employment by the total population of the same age group - *Empl.rate20-64,* respectively,*).*

Since voters' preferences on the magnitude of redistributive tax policies mainly depend on cultural, political, and social background at national level, we include: (i) institutional (time invariant) dummies for the legal origin of legal system (i.e. British legal origin - *LegBrit*; French legal origin - *LegFren*; Socialist legal origin - *LegSoc*; German legal origin - *LegGerm;* Scandinavian legal origin - *LegScand*[20]*)* or, as an alternative, country-dummies; (ii) institutional (time variant) variables to control for the political and economic institutional quality (i.e., the index of Economic Freedom - *EF*)[21]. (iii) cross-country invariant variables (period-dummies) or time trend, to control for the effects of financial crisis (i.e. 2008) and of institutional shock (e.g., Economic and Monetary Union) on tax progressivity. Lastly, we also include two interaction terms (*FI*EF, FI*TaxIncome*), to control for the effect of Fiscal Illusion on tax progressivity via both Institutional and public budget variables.

5.2 Estimation approach

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[20] It is taken as dropped dummy.
[21] The EF Index is based on 12 quantitative and qualitative factors, grouped into four broad categories: Rule of Law (property rights, government integrity, judicial effectiveness); Government Size (government spending, tax burden, fiscal health); Regulatory Efficiency (business freedom, labor freedom, monetary freedom); Open Markets (trade freedom, investment freedom, financial freedom).

As far as the estimation approach is concerned, the limited sample size (i.e., about 320 observations) and omission of some (not very) relevant determinants of tax progressivity may undermine the reliability of our results. Nevertheless, considering that we are not interested in determining the exact marginal effect but just if there is a statistically significant positive correlation between progressive taxation and misperception of tax price, potential sources of bias of small extented amount may be inconsequential for the aim of this analysis.

We perform redundant fixed effects and Hausman's tests to choose among pooled, fixed (FE) and random (RE) effects models. These tests suggest that a suitable specification for our model is a FE approach with country fixed effects. However, as robustness check, we also report findings based on models with RE and both time-invariant variables (i.e., dummies for the legal origin of legal system) and cross-country invariant variables (i.e., period-dummies).

Moreover, we apply the instrumental variable (IV) approach to control for potential omitted variable bias and reverse causality[22]. In particular, we treat as potentially endogenous regressors the following variables: *Index of Fiscal Illusion, Taxes on income as percentage of GDP* and the interaction terms *FI*EFI; FI*TaxIncome.* Provided that the IV approach requires the instruments to be correlated with endogenous variables and uncorrelated with the error in the tax progressivity equation (i.e., exogenous IVs), we identify the set of potential IVs based on the following theoretical arguments.

For the "*Index of Fiscal Illusion*", we use the *self-employment rate (GovExp)* and the *tertiary education (TertEdu) as IVs*. The hypothesis of relevance of these IVs is grounded on Dell'Anno and Dollery's (2014) which theorizes as a higher self-employment rate and a higher percentage of people who have completed tertiary education reduce policy makers' capability to distort the perception of the tax burden. The economic motivations are that: (i) self-employed persons have a greater awareness of tax burden than employees due to the limited use of withholding income tax for their income, and (ii) better educated people, with better awareness of the actual tax burden, dis-incentivize government's (ab)use of pro-illusion fiscal policies.

For "*Taxes on income as percentage of GDP*", we use the "*Total general government expenditure as Percentage of GDP*" *(GovExp)* — because, to keep the government budget in balance these two aggregate variables are expected to be correlated to each other — and the size of population as proxy of number of taxpayers as instruments.

For the interaction term between "*Fiscal Illusion and Economic Freedom Index*", we consider three sub-indexes of the *Economic Freedom Index*. In particular, we include *Trade Freedom* (it accounts for the trade-weighted average tariff rate and Non-tariff barriers), *Monetary Freedom* (it accounts for the weighted average inflation rate for the three most recent years and the extent of price controls) and *Corruption*, because we consider them as institutional factors having no direct effect on the top statutory PIT rate.

Lastly, we also include period-dummies among the included instruments to account for potential changes of national policies at European level in the period 1995-2008 (e.g., effect of Monetary Union, financial crisis, etc.).

As the hypothesis of exogeneity concerns, we do not find significant economic motivations to suppose that selected IVs (i.e., *Self-empl; TertEduc; GovExp; Population; Trade Fr.; Monetary Fr.; Corruption; period-dummies*) may be correlated to the error term in regression (5). Indeed, in our

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[22] We could hypothesize that top statutory PIT rate may influence FI. E.g., governments characterized by higher statutory PIT rate may need to use more pro-illusion fiscal policies to reduce taxpayers' perception of tax burden than governments with less progressive tax system. To control for reverse causality, we also estimate a FE model with lagged regressors (FE lag).

opinion, the only effect that these IVs may have on the country top statutory PIT rates should be mediated by government's decisions to adopt pro-illusion fiscal policies and/or variations of economic development. Accordingly, we consider the selected IVs as potentially suitable for our models. In the following, we report some illustrative findings based on two-stage least squares (TSLS) and generalized method of moments (GMM) estimators.

5.3 Results

Table 1 shows a selected output of statistical tests of regression (5).

Table 1: Dep. Variable: Top statutory Personal Income Tax rates

Model:	RE1	RE2	RE3	FE1	FE2	FE3	FE3(lag)	TSLS1	TSLS2	GMM
FI	13.84***	9.70***	9.82***	11.55***	12.27***	13.75***	14.92***	15.07***	10.26***	8.83***
	(4.17)	(3.66)	(3.83)	(2.43)	(2.62)	(5.12)	(4.26)	(6.05)	(4.18)	(10.90)
Tax Income	1.68***	2.22***	2.21***	2.32***	2.17***	2.25***	1.77*	2.28	-0.66	-0.03
EF	0.50**	-	-	-0.01	-0.14	-	-	-	-	-
RealGDPcap$_{t-1}$	-0.04	-	-	-0.06	-0.39***	-0.43***	-0.39**	-0.49***	-0.21	-0.27***
*FI*EF*	-0.17***	-0.10***	-0.10***	-0.11	-0.12	-0.14***	-0.14***	-0.14***	-0.14***	-0.11***
*FI*Tax Income*	-0.22*	-0.30**	-0.34***	-0.43***	-0.42***	-0.43**	-0.51**	-0.59***	-	-
Population	0.00	0.00**	0.00**	0.00	-	-	-	-	-	-
GovExp.	0.16	-	-	0.09	-	-	-	-	-	-
Gini grossInc	-0.09	-	-	0.26	-	-	-	-	-	-
Empl.rate20-64	-0.55	-	-	-0.63	-	-	-	-	-	-
Leg British	-4.95	-	-	-	-	-	-	-	-	-
Leg_French	-6.85	-	-	-	-	-	-	-	-	-
Leg_Socialist	-12.24**	-	-	-	-	-	-	-	-	-
Leg_German	0.91	-	-	-	-	-	-	-	-	-
Time Trend	-	-	-0.60***	-0.45	-	-	-	-	-	-
Dummies	*Years*	*Years*	*-*	*Countries*	*Countries*	*Countries*	*Countries*	*Countries*	*Countries*	*Countries*
Observations	*292*	*339*	*339*	*313*	*330*	*330*	*311*	*301*	*301*	*301*
# countries	*25*	*28*	*28*	*27*	*28*	*28*	*28*	*28*	*28*	*28*
Prob>F(χ^2)	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
Two-Stages Least Squares Specifications:										

Instrumented for TSLS1: FI; *Tax Income*; FI*EF; *FI_Tax Income;* Instrumented for TSLS2 and GMM: *FI; Tax_income; FI*EFI*
Excluded instruments: *Real GDPcap$_{t-1}$*
Included instruments*: Self-empl.; TertEduc; GovExp; Population; Trade Fr.; Monetary Fr.; Corruption; dummies(years).*

IV Diagnostics	TSLS1	TSLS2	GMM
1) Sargan/Hansen *J-test of* overidentification (p-value)	*0.378*	*0.689*	*0.689*
2) Endogeneity Test of endogenous regressors (p-value)	*0.571*	*0.927*	*0.927*
3) Underidentification test (Kleibergen-Paap rk LM statistic) (p-value)	*0.461*	*0.244*	*0.243*
4a) Weak identification test (Kleibergen-Paap rk Wald F statistic)	-	23.35[a]	23.35 [a]
4b) FI [(F-stat) First stage]	25.24		
4b) Tax Income [(F-stat) First stage]	24.68		
*4b) FI*EFI* [(F-stat) First stage]	10.67		
*4b) FI*Tax Income* [(F-stat) First stage]	35.91		

Note: *, **, *** denote respectively significance at 1%, 5% and 10%; significance levels are based on robust and clustered standard errors at the country level. [a] the Stock-Yogo critical value at 5% is 19.44.

Table 1 shows the robustness of $a_1 > 0$, and it validates Proposition 2.

As control variables are concerned, we find that both higher income tax burden (*Tax Income*) and lower economic development (*RealGDPcap$_{t-1}$*) lead to higher top statutory PIT rate. Economic Freedom Index, size of Population, Employment rate, Income Inequality and Government Expenditure do not have a statistically significant effect on top statutory PIT rate. With reference to interaction terms (*FI*EF, FI*Tax Income*), we find that the higher the economic freedom and income tax burden,

the lower the effect of fiscal illusion on tax progressivity (or similarly, the higher the FI, the lower the effect of EF and Income Tax burden on top statutory PIT).

With reference to IV diagnostics, we test: (i) instrument validity by Sargan/Hansen's test for overidentifying restrictions. Given that Hansen J-statistic p-value is greater than 5%, we cannot reject the null hypothesis that the instruments are valid; (ii) non-endogeneity of the regressors based on test statistics with robust and clustered standard errors at the country level. We find that the p-value is greater than 0.05, hence we cannot reject the null hypothesis that regressors are exogenous. Accordingly, the regressors may not actually be endogenous and IV approach may be not required because the null hypothesis implies that OLS is consistent and efficient; (iii) rank condition or under-identification test by Kleibergen-Paap rank test. Given that Kleibergen-Paap rk p-value is greater than 5%, we cannot reject the null hypothesis that the rank condition is not satisfied; (iv) the test on weak instruments is based on Stock and Yogo (2005) critical values for the F-statistics. We find that models TSLS2 and GMM2 do not suffer from the weakness of selected instruments because we reject the null hypothesis of weak instruments given that Kleibergen-Paap rk Wald F statistic is larger than Stock-Yogo critical values at 5%. For the model TSLS1, Stock and Yogo (2005) critical values are not available, therefore this test is not applicable. As an alternative test on weak instruments, we report the F-statistics of first stage regressions that, applying the standard rule of thumb for IV models with one endogenous variable, should be larger than 10. Due to unavailability of Stock-Yogo critical values for TSLS1, we apply the Limited Information Maximum Likelihood (LIML) estimator because LIML is more robust to weak instruments.[23] These findings are qualitatively the same as those based on TSLS1 and TSLS2 and GMM estimators.

Although the IV diagnostics are somewhat ambiguous (i.e., instruments are valid according to Sargan/Hansen J-test, IV approach may be not required because the regressors are exogenous, the rank condition is not satisfied and weak-instrument tests are not conclusive for model TSLS1), we find robust evidence that, independently of the applied panel data estimator (i.e., RE, FE, TSLS, GMM, LIML), the claim of Proposition 2 holds true in our dataset.

In conclusion, the positive sign of a_1 empirically proves that progressivity of the tax system is higher when pessimistic illusion is lower due to higher fiscal illusion strategies. Furthermore, this positive correlation between pessimistic fiscal illusion and tax progressivity may be considered as an indirect empirical evidence that the median-voter group, D_2, is, on average, composed by richer but less pessimistic voters as compared to voters in the D_3-group.

6   Concluding remarks

According to standard public choice models, optimal redistributive policies are expected to pursue the median voter's preferences, and due to the skewness of the income distribution, incumbents tend to increase both taxation and income redistribution. This result has been strongly influenced by a Meltzer and Richard (1981) assumption that voters do not suffer from fiscal illusion.

In this paper, we attempt to enrich the research on redistributive policy by removing this assumption. In an interesting study, Caplan (2007, p. 48) says, "economists have a love/hate relationship with systematic bias. As theorists, they deny its existence. As empiricists, they increasingly import it from other fields". Our aim is to avoid the methodological choice of denying the existence of systematic voter misperception by arguing that such misperceptions are important for

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[23] We omit to report LIML estimates for the sake of brevity.

understanding policy maker actions. In our view the progressivity of the tax system is optimally designed by the incumbent — in the sense that his/her rent is maximized — in such a way as to be re-appointed. Consequently, redistributive policies are inevitably affected by misperception characterizing voters in the median group and the nature of fiscal illusion (i.e., optimistic or pessimistic).

In our model, tax progressivity is chosen by a rent-maximizing incumbent under the retrospective voting hypothesis. According to the latter, voters opt for re-appointing or dismissing the incumbent depending, exclusively, upon (perceived) utility losses and benefits from taxes and public expenditure programs respectively. Most importantly, the policy maker is allowed to design public expenditure programs by using both selective public transfers (e.g., pork-barrel spending, special groups transfers) and public goods/services.

We infer the following main conclusions from our approach.

1.   Tax progressivity is decreasing with the size of pessimistic illusion of the median voter group (Proposition 2). Intuitively, if a higher level of public expenditure (compensation) is required by the set of decisive voters as a consequence of higher perceived tax prices, then progressivity is less profitable for the incumbent. This result has been validated by econometric analysis.

2.   The progressivity of the tax system is decreasing with the income of the median group (e.g., Meltzer and Richard 1981) if, and only if, illusion is of the pessimistic kind (Proposition 3). The economic intuition is that if a median voter characterized by pessimistic illusion becomes richer, then the incumbent is not willing to increase taxes on this (richer) median voter, that is, progressivity becomes less *profitable* for the incumbent.

Finally, it is worth highlighting that, within the framework of retrospective voting models, we find that voters with optimistic flawed information (i.e., a lower perceived tax price than the actual one) are more more likely to attract redistributive expenditures (selective transfers) than either pessimistic (i.e., a greater perceived tax price than the actual one) voters (Remarks 2 and 3). However, provided that the society is characterized, on average, by pessimistic voters, the most pessimistic voters in the society are inevitably penalized by the public tax-benefit system, since their votes are too expensive to be targeted by policy-makers. The latter result supports the standard conclusion by which better informed (e.g., educated, cognitively unbiased) people are inevitably more successful in attracting redistributive spending (Stromberg 2004, Robinson 2009).

Appendix

Proof of Proposition 1

Let Δ_1 be the amount of compensation required by the least demanding voter in $h(\varepsilon)$, Δ_2 the additional amount of compensation needed to persuade also the second voter in the $h(\varepsilon)$ vector, ..., and Δ_m the additional amount of compensation required to persuade the median voter. For each Δ_i the government opts for $\bar{g}$ or $\tilde{g}_i$ in such way as to minimize the cost of compensation which, at the aggregate level, is defined as $G = \bar{g} n^Y + \sum_{i=1}^{n} \tilde{g}_i$. Let $C_i(\cdot)$ be the cost of Δ_i; Δ_1 costs $C_1(\bar{g}) = \Delta_1 n^Y$ in the case of public goods/services. Instead, as far as the selective transfer Δ_1 is to be paid to the 50% +1 of voters, the cost of compensation through selective transfers is $C_1(\tilde{g}_1) = \Delta_1(n/2 + 1)$. As such, the government provides public goods/services when $n^Y \leq n/2 + 1$, and selective transfers when $n^Y > n/2 + 1$. The second voter in $h(\varepsilon)$ votes for the incumbent, if Δ_2 is compensated. If

Δ_1 is financed by $\tilde{g}$, then it must be the case that $\Delta_i \; \forall \; i = 2, \dots, m$ are financed by selective transfers as well, so that $\bar{g}^* = 0$. Instead, if Δ_1 is financed by $\bar{g}$, then the additional compensation Δ_2 costs $C_2(\tilde{g}_2) = \Delta_2(n/2)$ using the selective transfer, while $C_2(\bar{g}) = \Delta_2 n^{\gamma}$ by providing public goods/services. In general, the incumbent opts for $\bar{g}$ for the i-th additional compensation if $\Delta_i n^{\gamma} \leq \Delta_i(n/2 + k - i)$ holds, where $k = 2$ if n is even and $k = 3/2$ if n is odd. Formally, if $\gamma \leq \ln(n/2 + k - i)/\ln(n)$, the incumbent provides $\bar{g}$, otherwise it is less expensive to convince voters using $\tilde{g}_i$. Consequently, voters from $i = 1$ to $i = d \leq m$ are compensated by public goods/services (D_1-group), where d denotes the highest integer satisfying $\Delta_d n^{\gamma} \leq \Delta_d(n/2 + k - d)$ with $d \simeq n/2 + k - n^{\gamma}$, so that, recalling eq.(1), $\bar{g}^* = \alpha \theta_d y_d^{\varepsilon}$. Given $\sum_{i=d+1}^{m} i = m - d \simeq n/2 + k - 1 - (n/2 + k - n^{\gamma})$, the D_2-group consists of $m - d + 1 \simeq n^{\gamma}$ voters. Members of the D_2-group must perceive that they have been perfectly compensated for paid taxes. Therefore, public goods/services must be integrated with selective transfers such that $\tilde{g}_i = \alpha \left(\frac{\delta_i}{\beta_i} y_i^{\varepsilon} - \frac{\delta_d}{\beta_d} y_d^{\varepsilon} \right) \; \forall \; i \in (d+1, m)$. Evidently, the D_3-group is not receiving any selective transfer, so that under-compensation is obtained from non-excludable public goods/services only.

Proof of Proposition 2

If the variation of $\theta_i \; \forall \; i \in D_2$ is sufficiently small so that the $h(\varepsilon)$-ordering is preserved, then the implicit function theorem applies, so that

$$\frac{\partial \varepsilon^*}{\partial \theta_i} = \frac{y_i^{\varepsilon} \log y_i}{\sum_{i=1}^{n} y_i^{\varepsilon}(\log(y_i))^2 - \sum_{i=d+1}^{m} \theta_i y_i^{\varepsilon}(\log(y_i))^2} \quad \forall \; i \in D_2$$

where the denominator must be negative for any interior solution (second order condition), while the numerator is positive by construction.

Proof of Proposition 3

If the variation of y_i with $i \in D_2$ is sufficiently small so that the $h(\varepsilon)$-ordering is preserved, then the implicit function theorem applies, so that

$$\frac{\partial \varepsilon^*}{\partial y_i} = -\frac{(1-\theta_i) y_i^{\varepsilon-1}(\varepsilon(\log(y_i)+1))}{\sum_{i=1}^{n} y_i^{\varepsilon}(\log(y_i))^2 - \sum_{i=d+1}^{m} \theta_i y_i^{\varepsilon}(\log(y_i))^2} \quad \forall \; i \in D_2$$

where the denominator is the second order condition that must be negative for any interior solution. Then $\partial \varepsilon^* / \partial y_i$ is positive whenever $\theta_i < 1$, negative when $\theta_i > 1$, and nil for $\theta_i = 1$.

The database

Variable	Description	Source [Code]	Mean	Min	Max	Obs
ε	Top statutory personal income tax rates (including surcharges): proxy of tax progressivity.	Taxation trends in the European Union (Table 2). Available from https://ec.europa.eu /taxation_customs /sites/taxation /files/taxation _trends_report_2018 _statutory_rates.xlsx	44.67	0	92.9	392
FI	Index of Fiscal Illusion	Dell'Anno and Dollery (2014), Table 4	4.27	0	10	343
EF	The Economic Freedom index. 100 represents the maximum economic freedom.	Heritage Foundation (http://www. heritage.org/index/	65.95	42.90	82.6	382
Tax Income	Taxes on income as Percentage of GDP	Eurostat. Main national accounts tax aggregates [gov_10a_taxag]	11.23	4.50	29.5	392
GovExp.	Total general government expenditure as Percentage of GDP	Eurostat.Main national accounts - tax aggregates [gov_10a_exp]	44.0	30.7	63.5	388
RealGDPcap	Gross Domestic Product divided by midyear population in constant 2010 U.S. dollars (thousand).	World Development Indicators [NY.GDP.PCAP.KD]/1000	31.0	3.8	112.0	392
Population	Population at 1st January, total (thousand)	The QOG Standard Dataset 2019(Teorell et al. 2019) [eu_demd2jant]/1000	17510.7	376.4	82536.7	392
Empl.rate20-64	Employment rates: 20-64 Years, Total (percentage of active population)	The QOG Standard Dataset 2019(Teorell et al. 2019) [eu_empy2064t]	74.2	60.3	84.7	345
Gini grossInc	Estimate of Gini index in equivalized household market (pre-tax, pre-transfer) income, using Luxembourg Income Study data as the standard.	Solt (2016) - SWIID 5.1 [gini market]	46	33	58	388
Self-empl	Self-employed, total (% of total employment). Modeled ILO estimat.	The QOG Standard Dataset 2019(Teorell et al. 2019) [wdi_semp]	17.1	6.5	46.2	392
TertEduc	School enrollment, tertiary (% gross).	The QOG Standard Dataset 2019(Teorell et al. 2019) [wdi_gert]	51.2	7.4	94.7	364
Trade Fr.	The trade freedom score is based on two inputs: The trade-weighted average tariff rate, Non-tariff barriers. 100 represents the maximum degree of trade freedom.	The QOG Standard Dataset 2019(Teorell et al. 2019) [hf_trade]	77.6	46.8	89.2	382
Monetary Fr.	The score for the monetary freedom factor is based on two components: The weighted average inflation rate for the three most recent years, Price controls. 100 represents the maximum degree of monetary freedom.	The QOG Standard Dataset 2019(Teorell et al. 2019) [hf_monetary]	77.7	0.0	94.2	382
Corruption	The score for this component is derived primarily from Transparency International's Corruption Perceptions Index (CPI) for 2011.	The QOG Standard Dataset 2019(Teorell et al. 2019) [hf_govint]	62.8	10	100	382
Leg British	Identifies the legal origin of the Company Law or Commercial code. Legal origin British	Data used in (*) Treisman (2007) https://www.sscnet.ucla.edu/polisci/faculty/treisman /Papers/what_have_we_learned_data.xls	0.12	0	1	364
Leg_French	Legal origin: French		0.38	0	1	364
Leg_Socialist	Legal origin: Socialist		0.27	0	1	364
Leg_German	Legal origin: German		0.08	0	1	364
Leg_Scand	Legal origin: Scandinavian		0.15	0	1	364

Countries included in the empirical analysis: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom.

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