HELMHOLTZ
ZENTRUM FÜR
UMWELTFORSCHUNG
UFZ

UFZ Discussion Papers

Department of Economics

3/2017

Decentralization effects in ecological fiscal transfers – the case of Portugal

Nils Droste, Claudia Becker, Irene Ring, Rui Santos

April 2017

Publisher:
Helmholtz-Zentrum für Umweltforschung GmbH – UFZ
Permoserstr. 15
04318 Leipzig

ISSN 1436-140X

Decentralization effects in ecological fiscal transfers – the case of Portugal

Nils Droste[*], Claudia Becker[†], Irene Ring[‡], Rui Santos[§]

Abstract:

Portugal has a unitary system in which the central government transfers funds to lower government levels for their public functions. In 2007, Portugal introduced Ecological Fiscal Transfers (EFT), where municipalities receive transfers for hosting Protected Areas (PA). We study whether introducing EFT in Portugal incentivized municipalities to designate PA and has led to a decentralization of conservation decisions. We employ a Bayesian structural time series approach to estimate the effect of introducing EFT in comparison to a simulated counterfactual time series. Quantitative results show a significant increase in the ratio of municipal and national PA designations following Portugal's EFT introduction. The analysis furthermore places emphasis on the importance of relevant municipal conservation competencies and the role of local decision makers' motivations for PA designations. Results have important implications for conservation policy-making in terms of allocating budgets and competencies in multi-level governments.

Keywords: Bayesian structural time series, ecological fiscal transfers, fiscal federalism, municipal competencies, nature conservation, Portugal

JEL Codes: C32, H41, H72, Q57

[*] Nils Droste, UFZ – Helmholtz Centre for Environmental Research, Department of Economics, Permoserstr. 15, 04318 Leipzig, Germany & Martin-Luther University Halle-Wittenberg, Department of Economics, Große Steinstr. 73, 06108 Halle an der Saale, Germany, nils.droste@ufz.de, ORCID: 0000-0003-4357-9115

[†] Prof. Dr. Claudia Becker, Martin-Luther University Halle-Wittenberg, Department of Economics, Große Steinstr. 73, 06108 Halle an der Saale, Germany, claudia.becker@wiwi.uni-halle.de

[‡] Prof. Dr. Irene Ring, Technische Universität Dresden, International Institute Zittau, Markt 23, 02763 Zittau, Germany & UFZ – Helmholtz Centre for Environmental Research, Department of Economics, Permoserstr. 15, 04318 Leipzig, Germany, irene.ring@tu-dresden.de

[§] Prof. Rui Santos, PhD, Cense – Centre for Environmental and Sustainability Research, Universidade Nova de Lisboa, Campus de Caparica, 2829-516 Caparica, Portugal, rfs@fct.unl.pt

Acknowledgements

We thank the participants of the AURÖ 2016 and LACEA/LAMES 2016 conferences and colleagues at Cense and UFZ for helpful comments. All errors remain our sole responsibility. Furthermore, ND is grateful for financial support of the Heinrich Böll foundation (grant no. P118873).

1 Introduction

In the face of a rapid biodiversity loss (Millennium Ecosystem Assessment 2005) and the increasingly recognized importance of ecosystem services for human well-being (Millennium Ecosystem Assessment 2005; TEEB 2010), the role of public conservation becomes by no means less crucial. Particularly, the designation of protected areas (PA) can be considered an (ecological) public function (Ring 2002). Regarding this context, an innovative instrument has gained attention in recent years: *Ecological Fiscal Transfers* (EFT) change the redistribution of tax revenue by incorporating ecological indicators, for example, the existence of PA, into the fiscal transfer scheme. EFT have first been introduced in the Brazilian federal state of Paraná in 1992 and subsequently in 17 out of 27 Brazilian states (Vogel 1997; Grieg-Gran 2000; Loureiro 2002; May et al. 2002; Loureiro et al. 2008; Ring 2008a; Droste et al. 2015). Portugal has been the first state to introduce an EFT scheme on a national level in 2007 (Santos et al. 2012; Santos et al. 2015). From a theoretical perspective, EFT schemes have been proposed and simulated for Switzerland (Köllner et al. 2002), India (Kumar and Managi 2009), Indonesia (Mumbunan 2011; Irawan et al. 2014), Germany (Schröter-Schlaack et al. 2014), and France (Borie et al. 2014).

As such, EFT have a range of interesting features (Ring et al. 2011; Santos et al. 2012; Droste et al. 2015): i) they may not require additional budget but change the existing fiscal revenue redistribution (Grieg-Gran 2000; May et al. 2002; Ring 2008a) ii) they can incentivize nature conservation and thereby increase the supply of an underprovided public good (Grieg-Gran 2000; May et al. 2002; Ring 2008a; Droste et al. 2015); iii) they take local preferences and local knowledge into account since both in Brazil and Portugal they are general purpose transfer and responses are the choice of local decision makers (for an analysis of the local level in the Brazilian state Paraná see Sauquet et al., 2014); iv) transaction costs for the introduction of EFT are relatively low because they constitute a rather marginal

change in existing fiscal transfer schemes (Ring, 2008a; Vogel, 1997); and v) in the pioneering state of Paraná in Brazil, EFT even include criteria for the quality of PA management in the fiscal transfer scheme which may enhance not just quantity but also quality of conservation areas and measures (Loureiro et al., 2008). Regarding the outcomes of EFT, so far few studies have studied the effect of EFT on the designation of PA econometrically (see for example Sauquet et al. 2014).

Analyzing EFT in Brazil with an econometric panel data approach for 1991-2009, Droste et al. (2015) find evidence that introducing EFT creates an incentive effect for an additional designation of municipal PA. They furthermore find indications for a decentralizing effect in the introduction of EFT since especially municipalities respond by designating additional PA. In general, decentralization provides means to incorporate local needs and preferences in polycentric and multilevel governance systems (Rubinchik-Pessach 2005; Andersson and Ostrom 2008; Faguet 2014). In particular, decentralized conservation decisions can take into account relevant ecosystems that provide goods and benefits mainly to the local level but also conserve local habitat with endemic species and contribute to national and global conservation goals (Smith et al. 2009; Butchart et al. 2015). Hence, there are spill-over effects associated with local conservation action which can be internalized through a respective fiscal remuneration (Ring 2008b). Given budgetary constraints for local governments, recognizing such spill-overs can change relative costs of provision and thus induce an incentive for an increased provision of local conservation. Focusing on the decentralization effect of introducing ecological indicators within fiscal transfers systems, we analyze the Portuguese EFT scheme as a case study for the first implementation of EFT that consider local governments' conservation policies within national level fiscal transfer schemes. The Portuguese case may serve as a model for other countries and its effects on municipal PA designations thus embody policy relevance beyond the national scope.

Since 1993 municipalities in Portugal are formally permitted to designate their own PA and in 2008 a reform widened the range of municipal conservation competencies. In this context, we study whether the 2007 introduction of EFT in Portugal has incentivized municipalities to make use of their (enlarged) conservation competencies to designate PA, and in this sense, led to a decentralization of the decisions where to protect nature. Our research question therefore is: Did the introduction of EFT in Portugal support the decentralization of conservation decisions, namely increase municipal PA designations in relation to national PA designations? To this end, we employ the means of a Bayesian structural time series approach (Brodersen et al. 2015), which has the benefit of providing an estimated counterfactual time series for Portugal – simulating what would have happened without the intervention of introducing EFT; controlling for the simultaneous shift in nature conservation law. We are the first to assess the effect of a shift in a fiscal governance regime on conservation planning outcomes through a Bayesian simulation of a counterfactual time series (see for an application of voter behaviour with web search data Street et al. 2015).

The structure of the paper is as follows: section 2 introduces relevant literature on the theory of decentralization and fiscal federalism in relation to conservation governance; section 3 introduces a theoretical model of conservation decisions; section 4 provides background information on the relevant institutions in Portugal, namely the 2007 reform of the Local Finances Law that introduced the EFT scheme, and the conservation competencies of different governments to designate a range of PA categories, including the 2008 reform; section 5 gives the data sources and introduces the Bayesian structural time series approach; section 6 provides the results of analysis; in section 7 we conduct robustness checks; in section 8 we discuss our results, and conclude briefly in section 9.

2 Literature review – decentralization and nature conservation

The economic theory of fiscal federalism has its origins in the field of public finance (Musgrave 1959; Oates 1972; Oates 2005). As an early scholar on the subject Friedrich von Hayek (1945) argued that decentralized systems provide informational advantages since local actors have more precise information of the needs, preferences and conditions of their 'immediate surroundings' than a central actor. According to Qian and Weingast (1997) this assumption refers to both consumers and local governments. Another important contribution was provided by Samuelson's theory of pure public goods and public expenditure (Samuelson 1954; Samuelson 1955). For public goods where consumption is below national scale, say local public goods, local governments are assumed more efficient in providing the locally desirable level of output (Tiebout 1956; Inman and Rubinfeld 1997; Qian and Weingast 1997) – given the absence of economies of scale (Olson 1969). Because local constituencies may have different preferences and opportunity costs a local provision of regionally differentiable public goods maximizes welfare in comparison to a reference scenario of a central government providing an equal output level for all municipalities. Furthermore, the optimal level of provision of (local) public goods is also determined by the distribution of costs and benefits. Matching costs, benefits, and decision-making competencies was called the principle of 'fiscal equivalence', basically stating that for an optimal supply those who benefit from a provision of a public good should also bear the costs of provision, and therefore hold the competencies to decide on it (Olson 1969).

These theoretical models have been generalized into a proposition known as the 'decentralization theorem' (Oates 1972). However, since governmental structures cannot in every case coincide with the spatial coverage of the public good in question, interjurisdictional spillover effects may occur, e.g. by roads or clean rivers (Oates 2005) or species conservation (List et al. 2002). In such cases a fiscal transfer from a more central to a decentral governmental level can internalize such positive spillovers in the sense of a

Pigouvian subsidy (ibid., see also Zodrow and Mieszkowski 1986). Furthermore, it has been shown that even in the absence of informational asymmetries and a cheaper provision of particular public goods at a central government, decentralization can be beneficial in terms of welfare since projects of only local importance are realized (Rubinchik-Pessach 2005).

These contributions on optimal allocations of costs and benefits among government levels assume, to a greater or a lesser extent, a welfare maximizing governmental behavior (Brennan and Buchanan 1980; Feld 2014). Thus, at all government levels the respective actors assumingly seek to promote the interest of their people (Oates 2005). Such theory of optimal fiscal revenue allocation has been called the first generation fiscal federalism (ibid.). Since the assumption of a welfare maximizing government might not always be fulfilled, a second generation fiscal federalism has been developed in order to analyze the 'black box' of governmental behavior (Qian and Weingast 1997). Drawing upon the theory of the firm (Coase 1937), its updates, and public choice theory, Qian and Weingast (1997) develop a theory of how governmental actors react upon institutional incentives and informational constraints. Oates (2005) extends the second generation theory of fiscal federalism to budget constraints, risk-sharing insurances and self-enforcing mechanisms in intergovernmental settings. Latest work includes analyses of incentives and (de-)centralization tendencies (Weingast 2009; Weingast 2014), decentral governance quality in general (Faguet 2014), and in particular, the responsiveness of government spending to local needs (Faguet 2004; Borge et al. 2014). Local municipal actor involvement in national policy formulation has been analyzed regarding corresponding effects on successful implementation of those policies (Terman and Feiock 2014), and in terms of causal relations of municipal spending and taxing behaviors to either locality bound micro incentives or institutional macro-level structures (Smith and Revell 2016).

Observations of state-federal conflicts regarding environmental public functions have led to a general analysis and comparison of command and control, taxes and tradeable permits

(Williams 2012). Boadway and Tremblay (2012) identify environmental federalism and the governance of natural resource as unsolved challenges for future research and particularly name the organization of regulatory competencies, intergovernmental fiscal relations and incentive structures within multi-level governments as knowledge gaps. In this context, urban conservation behavior under budget constraints and the fiscal implications have been modeled from a micro-economic perspective (Wu 2014) but without considering a multi-level structure.

We draw upon this body of literature, study municipal behavioral responses to fiscal incentives within multi-level government structures, and extend it into the direction of the provision of those public goods that are eminently supplied by protected areas (PA) – such as biodiversity conservation (Ring 2002; Perrings and Gadgil 2003; Ring 2008b). PA are mostly designated at higher levels of government but management and opportunity costs related to these areas mostly occur at local levels. EFT compensate for foregone income, thus lower opportunity costs of hosting PA for local jurisdictions and potentially incentivize PA designations. Our argument is thus twofold. Firstly, EFT may compensate for management and/or opportunity costs at the local level that are incurred through the realization of (supra-) national conservation interests. Secondly, EFT may create an incentive for the designation of decentral PA through a change in conservation costs by a per area transfer for PA. This two-sided argument reads as follows.

On the one hand, there are national conservation interests, such as providing a high connectivity habitat network across the nation or the protection of large and nationally important sites through national parks. Furthermore, there even are supra-national interests such as the European Natura 2000 network that ensures a protection of important habitats and species across Europe. For these cases of overarching interests a central planning is better suited than a decentral implementation, since local decision makers are unlikely to consider these (supra-) national interests in their rationale unless fully internalized. Such internalization

is difficult to realize since both opportunity and management costs of a habitat network may well differ across sites and regions and would thus require a spatially differentiated scheme in order to fully internalize the overarching interests in local decision making. EFT however, are generally lump-sum transfers that are not regionally differentiated. Through a uniform per area rate they may only (partially) compensate for opportunity costs incurred to the local level. Such a (partial) compensation may nevertheless lower the resistance of local jurisdictions to PA planned and designated at higher levels of government.

On the other hand, most of the benefits from PA are of a regional nature, such as health, recreation and amenity services (ten Brink et al. 2013). Additionally, there are the positive spillover effects to the state, national and even the global level which originate from those services with a long spatial (and temporal) range such as climate regulation, biodiversity maintenance or water regulation (ibid.). We assume that those services may not just be provided by national PA but also by local ones, but spatial spill-over benefits are often not internalized in local decisions. Since costs and also benefits differ among location and conserved habitats, a uniform EFT scheme would not internalize these positive external effects in a targeted manner but still create an incentive to increase decentral provision of PA. The incentive effect lies in the change in the benefit-cost ratio. If, for example, every per cent of a local jurisdictions territory that is put under protection receives a transfer quota, this reduces the price of providing local PA and therefore, likely yields additional local PA. Furthermore, this incentive effect would be greatest where the preferences for a local PA are largest and thus a change towards a positive net gain is most likely.

Considering these two sides of EFT, theoretically they lead to welfare gains by: a) reducing local costs through compensation for burdens incurred by centrally planned PAs, and b) better taking into account both local preferences and positive spatial externalities in the designation of smaller scale, local conservation areas.

3 Theoretical model - local public conservation decisions

There can be a range of factors ultimately determining local decision maker's conservation spending and regulation decisions. Starting from a neoclassical textbook definition, local decision makers could be considered as rational actors optimizing pay-offs corresponding to their preferences (or arguments of their utility function). It has been noted that such rationality is bounded by cognitive capacities (Simon 1955), that commitment is a fundamental part of decision making (Sen 1977) and that institutions define actions at least as much as intrinsic motivation (Ostrom 1990; Vatn 2007). Furthermore, local governments are no unitary actor but consist of multiple actors that all have their own agenda beyond the collectively defined one.

There is, however, no doubt that local governments face budget constraints. Let us consider a situation where a local decision maker has to decide between spending public budget on either conservation policy or some other public good out of all possible ones. The outmost boundary is given by the budget constraint, such that all available income Y is spent on either conservation action A at price p_a or a composite public good B at price p_b (equation 1).

$$Y = p_a A + p_b B \tag{1}$$

Canonically, the optimal choice regarding quantities of A and B is determined by both relative prices and marginal utilities U'_a and U'_b, such that $\frac{p_a}{p_b} = \frac{U'_a}{U'_b}$. Given a policy that induces a price change, such a per unit fiscal transfer for PA, say from p_a to p'_a (see section 4 for details), may lead to a greater quantity of conservation action, ceteris paribus. For the sake of simplicity, let us assume that both goods are normal goods, and that there is some degree of substitutability between the two public goods. Then, $\Delta A = A(p'_a, Y) - A(p_a, Y) > 0$ if $p'_a < p_a$.

From this simplistic model we would thus hypothesize that introducing fiscal transfers for PA leads to an increase in PA, given that PA spending leads to PA designations. There are, however, many more factors that determine the decision making of local government agents including various, right-based considerations, attitudinal beliefs and other intrinsic motivations beyond just monetary considerations (cf. works on factors determining willigness-to-pay for conservation Kotchen and Reiling 2000; Spash 2006; Ojea and Loureiro 2007; Spash et al. 2009). While such motivations may also alter the degree to which monetary considerations are taken into account in public administration and political conservation decision making, we would nevertheless base our analysis on the following simplifying hypothesis: *if designating PA becomes a source of income for local governments we will likely be observing an increase in corresponding conservation action.*

4 Institutions – ecological fiscal transfers and conservation competencies in Portugal

While Portugal has a unitary government, there are some municipal and regional (fiscal) competencies, regarding e.g. taxation (Costa and Carvalho 2013) or water management (Thiel 2015). In this section we elaborate on the institutional context in Portugal concerning i) the introduction and functioning of ecological fiscal transfers (section 3.1) and ii) the municipal and regional competencies in nature conservation, focusing on the designation of PA (section 3.2).

4.1 Ecological Fiscal Transfers

The Portuguese EFT were introduced through the Portuguese Local Finances Law (*Lei das Finanças Locais nº 2/2007*) reform in 2007 (Santos et al. 2012). The law establishes new rules for revenue distribution and fiscal transfers from central government funds to the local level, and was reformed again in 2013 but without a change in the EFT component (*Lei n° 73/2013 do regime financeiro das autarquias locais e das entidades intermunicipais*). On average the transfers account for about 44 per cent of total municipal income during 2007 – 2014

(Direção-Geral das Autarquias Locais 2015) while the rest is levied by municipal taxes on e.g. property, income and business (Santos et al. 2012; see also Costa and Carvalho 2013).

There are three main national funds for disbursement of public revenue among municipalities. The Financial Equilibrium Fund (*Fundo de Equilíbrio Financeiro*) is a general grant with a value of 19.5 per cent of the arithmetic mean of income tax, corporate tax, and value added tax revenues (in 2007 it was 25.3 per cent). The Financial Equilibrium Fund is divided into two sub-funds with 50 per cent each, the General Municipal Fund (*Fundo Geral Municipal*) and the Municipal Cohesion Fund (*Fundo de Coesão Municipal*) for fiscal imbalances (Santos et al. 2012; Direção-Geral das Autarquias Locais 2015). Moreover, there also is the Municipal Social Fund (*Fundo Social Municipal*) for expenditures on social public functions such as education, health and welfare. Additionally, a 5 per cent share of the income tax also goes directly to the municipalities (Santos et al. 2012; Direção-Geral das Autarquias Locais 2015). Beyond those national funds, there are also transfers from the European Union to municipalities (Direção-Geral das Autarquias Locais 2015).

With regard to ecological fiscal transfers the funds' allocation functions the following way. Among other criteria, 5 per cent of the General Municipal Fund (GMF) are allocated in proportion to the area under protection (Natura 2000 and other PA). In case more than 70 per cent of the municipal area is under protection the ecological component portion becomes 10 per cent – which reduces the otherwise 25 per cent of the GMF redistributed according to area to 20 per cent (Lei n.º 2/2007 and Lei n.º 73/2013). This makes EFT 2.5 – 5 per cent of the Financial Equilibrium Fund. It is important to note, however, that the ecological fiscal transfers are general purpose transfers without any earmarking. While the allocation of ecological fiscal transfers in Portugal is based on the existence (and expanse) of PA, the municipalities can spend the respective income on whatever public function they consider necessary. Figure 1 gives an overview of the structure of fiscal transfers in general and the ecological fiscal transfers in particular.

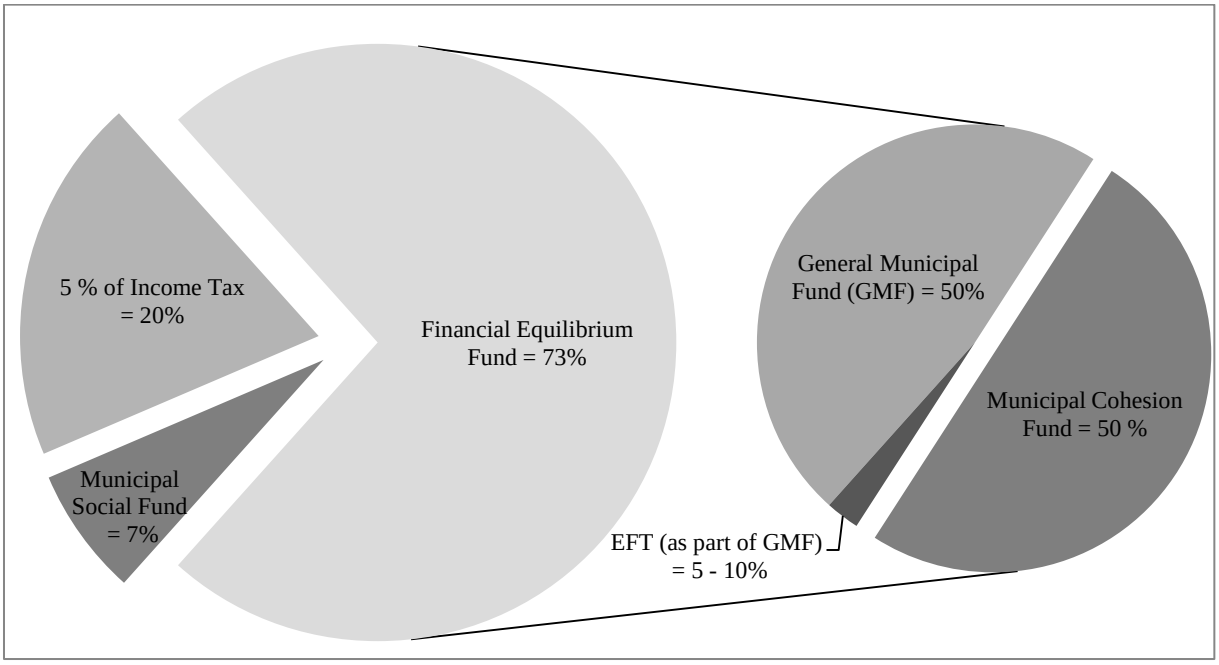

Figure 1: 2015 fiscal transfer funds and ecological fiscal transfers (EFT) in Portugal, authors' elaboration based on data from Direção-Geral das Autarquias Locais (2015). The left bubble represents the 2015 distribution funds (taxes vary), while the right bubble is defined by law (both general and cohesion fund are always 50 per cent of the equilibrium fund).

4.2 Nature conservation competencies

The competencies regarding the designation of PA in Portugal are divided between the national, the local, and the private level. In Table 1 there is an overview of different PA categories per government level. We briefly introduce each in turn.

The European Natura 2000 network site selection is based on lists of ecologically important natural habitats and species, known as Sites of (European) Community Importance (Evans 2012). Based on these lists the Portuguese national authorities decide upon the designation of Special Areas of Conservation (SAC) under the Habitat Directive and the Special Protection Areas (SPA) under the Birds Directive.

The national authorities (i.e. the Environmental Ministry and its agency, the Institute for Nature Conservation and Forests (*Instituto da Conservação da Natureza e das Florestas – ICNF*) can designate all IUCN (International Union for the Conservation of Nature) PA categories such as national parks, nature parks, nature reserves, protected landscapes areas and nature monuments (Decreto Lei n.° 142/2008).

The municipalities or regional associations of several municipalities may designate all these PA categories except national parks. It is important to note that while the law decree 19/1993 defined that municipalities and municipal associations can *propose* the designation of only a regional protected landscape area to the ministry, the law decree 142/2008 widened their competencies and authorizes them to directly *designate* all PA categories but a national park. However, out of the eight regional and local PA designated on basis of law decree 142/2008 only three are not protected landscapes areas, meaning there are relatively few responses to the 2008 widening of municipal PA designation competencies regarding the type of designated PA. In practice, the change from proposing a local PA and designating it at the local level can be considered a fairly slight change. Furthermore, the 2008 reform allowed explicitly for the designation of private protected areas. So far, there is one private PA (Faia Brava). Except the Natura 2000 sites, these protected sites altogether constitute the national network of protected areas (*Rede Nacional de Áreas Protegidas – RNAP*).

In this context, it is worth noting, that the Natura 2000 network in 2010 covered 18.8 per cent of continental Portugal, while the RNAP only accounted for 7.9 per cent (INE 2015) and in 2013 Natura 2000 covered 20.7 per cent of entire Portugal (EU 2015) while the RNAP accounted for 8.5 per cent of Portugal (ICNF 2015). This is due to the special nature of Natura 2000 sites which are not necessarily to be designated as PA under national law but managed according to EU law. The EFT mechanism, however, accounts for both Natura 2000 and RNAP sites.

Table 1: Protected area (PA) designation competencies of different governmental levels and their legal foundation (based on ICNF, 2015; see also Santos et al., 2012).

Designating body	**PA categories**	**Legal foundation**
National authorities	- Special Area of Conservation - Special Protection Area	- EU Habitats Directive - EU Birds Directive
National authorities	- National Park - Nature Park - Nature Reserve - Protected Landscape Area - Nature Monument	- Decreto-Lei n.º 19/93 - Decreto-Lei n.º 142/2008
Regional and local municipal authorities	- Nature Park - Nature Reserve - Protected Landscape Area - Nature Monument	- Decreto-Lei n.º 19/93 - Decreto-Lei n.º 142/2008
Private	- Private PA	- Decreto-Lei n.º 142/2008

5 Empirics – Bayesian structural time series analysis

5.1 Data

We collected data on designated protected areas from the Institute for Nature Conservation and Forests (ICNF) that account for the national network of protected areas but do not include Natura 2000 areas except those parts that are spatially overlapping with the national PA (ICNF 2015), and socio-economic controls representing the general structure of the economy such as GDP per capita, population density, valued added by the agricultural, industrial, and service sectors from the World Bank (2015), and controls representing conservation preference proxies such as data on members of environmental NGO per 1,000 inhabitants, municipal spending and income related to the environment (regarding climate and air quality, waste water treatment, residual waste treatment, water protection, noise reduction, biodiversity and landscape protection, radiation control, research and development and other

environmental protection) from the National Statistics Institute (INE 2015). All monetary values are given in constant € 2005 prices (deflated based on the World Bank GDP deflator for Portugal or calculated in Euro with average US dollar exchange rates for 2005). This way, we constructed a multivariate time series for Portugal from 1995 to 2014 with yearly observations. Summary statistics and time series of PA data can be found in the appendix, and the compiled raw data and code for reproducing results is provided online (https://github.com/NilsDroste/EFT-PT).

5.2 Econometric model

Since we want to estimate the effect of the 2007 EFT introduction on the degree of centrality in conservation decisions, measured by the ratio of municipal and national PA designations, we employ a model constructing an appropriate counterfactual via a synthetic control. The *CausalImpact* package (Brodersen et al. 2015) within **R** (R Development Core Team 2016) provides such an implementation by employing a Bayesian structural time series approach. Originally designed to infer effects of online marketing interventions *CausalImpact* estimates the difference between the observed time series of the response variable and a simulated (synthetic) time series that would have occurred without the intervention (Brodersen et al. 2015). The synthetic control is basically built through three sources of information: i) the dependent time series behavior prior to invention, ii) covariate time series pre-intervention behavior with predictive power for the response variable time series, and iii) if existent, available prior knowledge about the model parameters since it is a Bayesian framework (ibid.).

The Bayesian structural time series model is a state-space model for time series data which can be defined as a pair of equations:

$$y_t = Z_t^T \alpha_t + \varepsilon_t. \quad (2)$$

$$\alpha_{t+1} = T_t\alpha_t + R_t\eta_t. \quad (3)$$

where $\varepsilon_t \sim N(0, \sigma_t^2)$ and $\eta_t \sim N(0, Q_t)$ are error terms independent of all other unknowns (Brodersen et al. 2015). Equation 1 is the *observation equation* where the response variable y_t is linked to a *d*-dimensional state vector α_t and an independent and identically, normally distributed error term ε_t. Equation 2 is the *state equation* that covers the behavior of state vector α_t. Here, $Z_t \in IR^d$ denotes an output vector, the matrices $T_t \in IR^{d\times d}$ and $R_t \in IR^{d\times q}$ are transition and control matrix, respectively, and $Q_t \in IR^{q\times q}, q \leq d$ denotes the state-diffusion matrix of the above mentioned system error $\eta_t \in IR^q$, see Brodersen et al. (2015: 252). For more details on components of the state equation, such as local trends, seasonality and coefficients of contemporaneous covariates see Brodersen et al. (2015).

We employ this Bayesian structural time series framework to estimate the effect of EFT introduction (our intervention starting in 2007) on the ratio of municipal and national PA, including socio-economic variables' time series, namely GDP per capita, population density, valued added by each the agricultural, industrial, and service sectors, members of environmental NGOs per 1,000 inhabitants, and municipal spending and income related to the environment (for data sources see section 4.1). These variables are included according to the spike-and-slab prior of the predictors (the spike places a positive probability mass at zero for the coefficients, the slab poses the prior parameter distribution close to flat, and the models include nonzero predictors) (Scott and Varian 2014). The model algorithm chooses an appropriate set of covariates within a forward-filtering, backward-sampling framework, based on a Kalman filter (the filter recursively computes the predictive distribution $p(\alpha_{t+1}|y_{1:t})$ moving forward through the time series, while the Kalman smoother moves backward through time updating the output of the Kalman filter) (ibid.). The algorithm averages the final model over parameter value results of a Markov chain Monte Carlo (MCMC) simulation of several model draws that are each based on the spike-and-slab prior and thereby include different

(sub-)sets of controls (George and McCulloch 1997; Scott and Varian 2014; Brodersen et al. 2015). This allows reporting both the marginal inclusion probability and the marginal probability of e.g. a positive parameter coefficient. In our case we set the number of MCMC model draws to 1,000, the default value of the *CausalImpact* package. The posterior causal inference is based on: the model parameter draws during the pre-intervention training period, the posterior simulation of a post-intervention counterfactual time series given the pre-intervention activity, and a post-intervention difference between observed time series and counterfactual prediction (Brodersen et al. 2015).

6 Results – decentralization effects in Portuguese EFT

During the post-intervention period, namely after the introduction of the EFT, the response variable, that is to say the ratio of municipal and national PA, had an average value of approximately 0.30. By contrast, in the absence of the intervention, we would have expected an average response of 0.13 with a 0.02 standard deviation (sd). The 95% confidence interval (ci) of this counterfactual prediction is [0.09, 0.18]. Subtracting this prediction from the observed response yields an estimate of the causal effect the intervention had on the response variable. This effect is 0.17 with a 0.02 sd and 95% ci of [0.13, 0.22]. This means that if we predict the development of the ratio of municipal and national PA numbers during the post-intervention period, given the pre-intervention period correlations of the control variables and the post-intervention development of these variables, the observed ratio is about 0.17 higher than we would have expected.

Summing up the individual data points during the post-intervention period, estimating a cumulative impact, the response variable of the ratio of municipal and national PA counts had an overall value of 2.13. By contrast, had the intervention not taken place, we would have expected a sum of 0.94 with a sd of 0.15 and a 95% ci of [0.60, 1.23]. The above results are given in terms of absolute numbers. In relative terms, the response variable showed an

increase of +121% with a sd of 15% . The 95% ci of this percentage is [+95%, +162%]. The probability of obtaining this effect by chance is very small (Bayesian tail-area probability p = 0.001). This means that the positive effect observed during the intervention period is statistically significant and unlikely to be due to random fluctuations. Summarizing, our estimation shows that the ratio of municipal and national PA numbers has significantly increased after EFT were introduced in Portugal, which we infer to be a consequence of the fiscal incentive effect that is inherent in designating a percentage of tax income transfers to municipalities according to ecological criteria. For a graphical result of analysis see Figure 2.

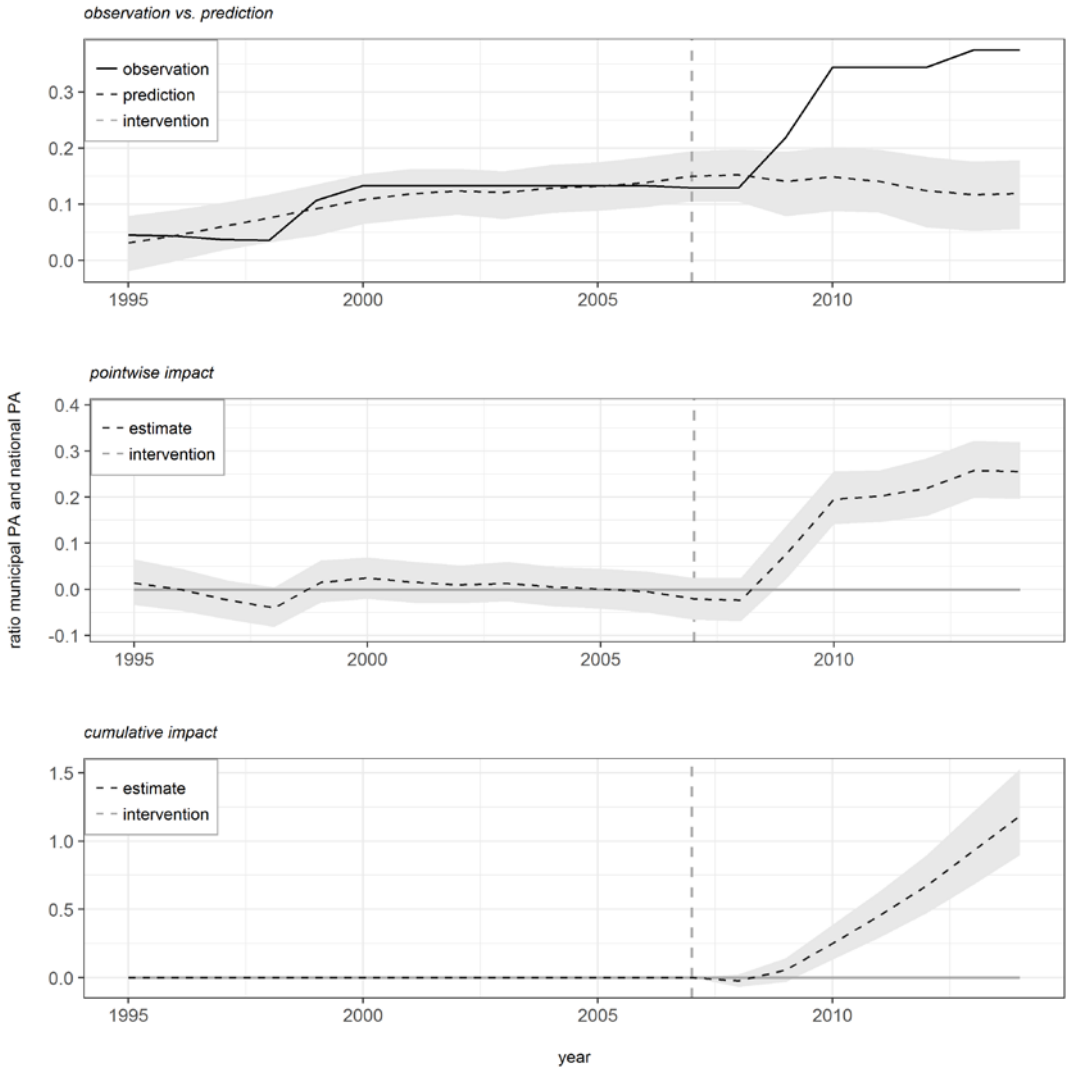

Figure 2: Graphical illustration of Bayesian structural time series model i) observation vs. prediction, ii) pointwise impact and iii) cumulative impact estimates, all with grey shade as uncertainty range between upper and lower limit estimates. Source: authors' computation.

Figure 3 displays the marginal posterior inclusion probability of control variables. This gives insight into how the different draws from models are structured and about the average probability of the sign of coefficients. It shows that GDP per capita is by far the most predictive covariate with regard to the ratio of municipal and national PA numbers and has a positive sign. Similarly, but with less predictive power, population density also has a positive sign, and less so value added by the service sector (which accounts for a large portion of GDP per capita). The other covariates have a lower probability of a positive sign, except for the members of environmental NGO per 1,000 inhabitants which most probably has a negative sign and a relatively low predictive power since it is rarely included in models drawn from 1,000 simulated models.

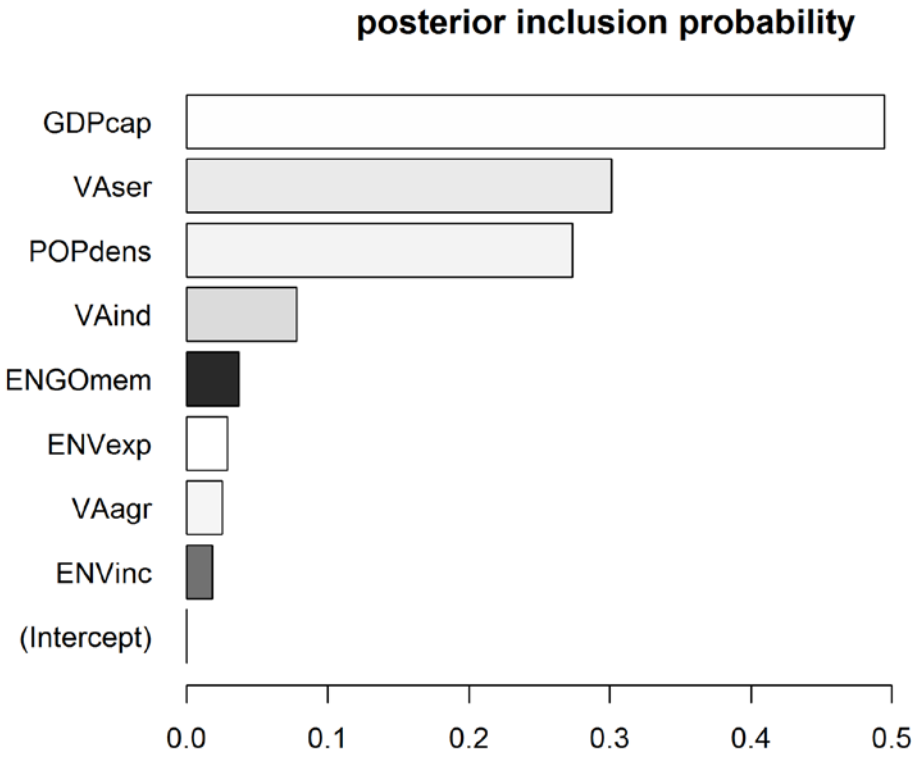

Figure 3: Marginal posterior inclusion probability of variables in 1,000 model draws. Color shades are in proportion to the probability of a positive coefficient on a continuous [0, 1] scale: negative coefficients are black, positive coefficients are white, and gray indicates an indeterminate sign, of a probability of a positive coefficient around 0.50) (Scott and Varian 2014). Variables are (with probability of a positive coefficient in parentheses): GDPcap is GDP per capita (0.99), POPdens is population density (0.95), VAser is value added by the service sector (0.92), VAind is value added by industrial sector (0.86), ENVexp is the environmental municipal expenditure (1.00), ENGOmem are members of environmental NGOs per 1,000 inhabitants (0.16), VAagr is the value added by agricultural sector (0.96), and ENVinc is the environmental municipal income (0.44).

7 Robustness checks

Because there was a reform of the PA designation competencies in 2008, just after the introduction of EFT in 2007, we conduct a robustness check for this second and almost simultaneous regime shift. This check consists in excluding those three municipal, respectively regional municipal association, PA designations (in terms of the number of PA designated) from our data set that have only been possible with the reform of the nature conservation competencies (the regional Natural Park Vale do Tua, the local Natural Reserve Estuário do Douro, and the local Natural Reserve Paul de Tornada). The result shows that the estimated causal effect would be lower than our initial analysis but the results would still be significant. The difference between observed post-intervention average of the response (0.24) and the prediction without an effect (0.13 with a 0.02 sd and a 95% ci of [0.08, 0.17]) would be 0.11. In relative terms, the response variable showed an increase of +79% (17% sd). The 95% interval of this percentage is [+49%, +116%]. The Bayesian tail-area probability is p = 0.001, hence, even when excluding those above mentioned PA designations, that have only been possible with the law decree 142/2008 reform of municipal nature conservation competencies, we consistently estimate a significant causal effect with this model.

Since national-level PA are on average larger in size than municipal PA and we are interested in the decentralization effect regarding PA designations we measured the dependent variable as the ratio of municipal and national PA. However, conservation is not just about the number of PA but also about their expanse. Therefore, as another robustness check, we repeat the analysis with the respective ratio of the area in hectares of municipal and municipal PA (see appendix A 2 for some detail). The results show a similar but weaker effect – which is due to the difference in sizes of municipal and national PA. The observed post-intervention average of the response is 0.027 and the counterfactual prediction 0.014 with a 0.0027 sd and a 95% ci of [0.006, 0.019] which means an estimated effect of 0.012 (sd 0.0027, ci [0.0076, 0.02]). In relative terms, the results are comparable to the analysis of PA numbers: the

response variable showed an increase of +85% (18% and a 95% ci of [+53%, +139%]). The Bayesian tail-area probability is p = 0.001,

However, if we proceed to estimate the EFT effect on the ratio of municipal and national PA in terms of area covered and also exclude those municipal PA that have only been possible with the 2008 reform of municipal conservation competencies, there is no longer a significant effect. Predicting a counterfactual response of 0.014 (sd 0.0027, 95% ci [0.007, 0.019] we fail to reject the null hypothesis of a significant difference to the observed ratio of 0.017. This is due to the fact that the area-related effect is mainly driven by one singular municipal PA, namely the regional Natural Park Vale do Tua. This regional park has been designated in 2013 and, with a size of about 24,767 hectares, comparable to the size of national PA. It has furthermore been designated by a regional association of the municipalities of Alijó, Murça, Vila Flor, Carrazeda de Ansiães, and Mirandela (ICNF, 2015). This means that in terms of PA area, the introduction of EFT in Portugal was not as important as the widening of municipal conservation competencies.

8 Discussion – municipal competencies, welfare gains, and knowledge gaps

Quantitative results show that the introduction of EFT is followed by an increase in the ratio of municipal and national PA numbers. While national authorities keep designating PA, municipalities designate more of their own PA categories than previous to the introduction of the scheme such that the ratio rises. Through a comparison of this ratio with a simulated counterfactual time series predicted from pre-intervention correlations, we infer this to be a consequence of the EFT introduction. Given the Bayesian structural time series approach, these results suggest decentralization in nature conservation decisions through EFT. While we cannot directly infer the actual motivations of decision makers for designating additional municipal PA from these results, we can observe a synchronicity of events in the time series, where the rise in the ratio of municipal and national PA coincides with the introduction of

EFT in Portugal. Given our theoretical public budget decision making model, this can be understood as a consequence of assigning a portion of fiscal transfers to the existence of (municipal) PAs.

For the discussion of our results we focus on four specific aspects: i) the statistical application of a Bayesian structural time series approach and its validity, ii) municipal nature conservation competencies and their importance for the functioning of EFT, iii) welfare implications of decentralization through EFT, and iv) open research questions about motivational aspects of conservation decisions.

8.1 Bayesian structural time series application and its implications

The application of a method originally designed for assessing causal impacts of marketing interventions to the introduction of an economic instrument for nature conservation such as EFT, produced interpretable and sensible results. This mainly is a consequence of a neat implementation of the *CausalImpact* package within the **R** environment and the merits of the Bayesian framework. While the spike-and-slab prior allowed obtaining relatively sparse but predictive models, the MCMC simulations allowed a model averaging regarding the inclusion of the most predictive covariates. Building upon these algorithms, predicting a counterfactual time series is the key feature of the Bayesian structural time series approach. Thereby it provides a solution to a fundamental and long standing issue in econometric analysis of causal effects, the problem of not having a controlled experimental setting in analyzing real world phenomena or policies (cf. Box and Tiao 1975; Ashenfelter and Card 1985; Meyer 1995; Heckman 2008; Athey and Imbens 2015).

Another statistical issue is the required length of the time series. While, for example, Box et al. (2016, p. 15) state that long time series of about 50 to 100 observations are required for proper analysis, i.e. for data with seasonal variability, Simonton (1977) argues that for cross-sectional analyses time series with 4 to 12 observations per case can suffice. Hyndman

and Kostenko (2007) state that it is at least required to have more observations than parameters but also differentiate between requirements for standard time series analysis methods such as regressions with seasonal dummies, Holt-Winters Methods and ARIMA models. They suggest a Bayesian framework for cases in which data is limited – which applies to our case. Furthermore, requirements may reduce if regularizing methods are applied (Hyndman 2014). This is to say requirements very much depend on the data structure, the nature of the observed variables and the modeling approach.

In our data set we have yearly data of the dependent and 8 independent variables for the 13 years of the pre-intervention period, and 7 years for which the dependent variable is both observed and predicted as a counterfactual based on the pre-intervention correlations and post-intervention variability of covariates using regularizing priors (Brodersen et al. 2015). There is no seasonal variability in the dependent variable and a rather stable (close to linear) trend, and apparently rather static coefficients in the pre-intervention period without much random variation in the development of our dependent variable over time. Thus, we assume that a Bayesian prediction of a simulated counterfactual time series that takes into account the known post-intervention variation of covariates suffices for a reliable post-intervention estimation, especially since the technique has particularly been developed for short time series forecasting (Scott and Varian 2014).

One potential shortcoming of the model is that covariates such as GDP per capita, population density and value added are potentially endogenous such that designating municipal PA may attract investments or inhabitants through local amenities. In general, such endogeneity may affect our results. However, there are two reasons why we assume those to be negligible, one circumstantial and the other methodological: i) considering the circumstances of the banking and fiscal crisis starting 2007, the relative importance of municipal PA for GDP and value added appears to be minimal and population movement might be more affected by employment than by local amenities; ii) while designating a

municipal PA takes immediate effect, the change in habitat structure and quality and thus local amenities through conservation action require longer time, such that the prediction based on contemporaneous covariates would not be affected by lagged effects of the dependent variable on covariates.

8.2 Conservation competencies and their importance for the functioning of EFT

Our results regarding a decentralizing effect of introducing EFT are robust to the exclusion of the *number* of those three municipal PA designations that only have been possible with the 2008 reform of municipal nature conservation competencies. However, they are not robust if the EFT effects are computed on the ratio of municipal and national PA in terms of area covered, when at the same time excluding those municipal PA that were only possible withthe 2008 institutional change (see section 6).

This shows the importance of municipal competencies for the functioning of the instrument. They are important in two ways: a) considering the incentive effect of EFT and b) considering conservation effectiveness.

Regarding the incentive effect, municipalities may be more inclined to designate an additional PA when obtaining fiscal transfers for hosting PA since additional funds for PA increase obtained benefits (which may be pluralistic in their value or arguments to a utility function). If these benefits exceed costs (which are more likely financial or in terms of opportunity costs), there is an incentive to designate a municipal PA. Any local response in terms of an outcome variable to such an incentive effect will, however, only occur if municipalities have any competency to designate PA or influence the outcome. Otherwise municipalities may still be more inclined (or less resistant) to host PA designated by higher levels but they will legally not be allowed to designate municipal PA themselves and can thereby not respond directly to the incentive effect. Both in Brazil (where EFT originated) and in Portugal municipalities have competencies to designate municipal PA but this is no

universal feature. As a general rule of thumb one can assume that municipal nature conservation competencies increase in the IUCN PA categories. While it is rather unlikely that municipalities designate large-scale PA such as a national park (e.g. categories I and II), the less stricter PA may well be expected to be designated (and managed) by municipalities (especially categories such as natural monuments, category III, landscape protection areas, category V, or protected areas with sustainable use, category VI). However, municipal planning and policy competencies for conservation have increased since the implementation of the Agenda 21 although their inclusion still poses a challenge for sustainable development (Nolon 2005). Hence, the effects that EFT can have on the designation of municipal PA in Brazil (Droste et al. 2015) or in Portugal can very likely not be replicated in other countries unless there are comparable nature conservation competencies in place for the designation of municipal PA.

Regarding conservation effectiveness, the overall area covered by PA can be considered one, very important but unidimensional factor (cf. Gaston et al. 2008; Gray et al. 2016). Given that decentral authorities in Portugal have the competency to designate large scale PA through a joint designation of several municipalities EFT could be considered beneficial for conservation effectiveness in terms of PA extent – but the 2008 nature conservation reform that widened the municipal compentencies can be considered as important for such an effect. Nevertheless, there may be additional benefits of of small-scale municipal PA, e.g. for habitat connectivity and more equally distributed PA networks (cf. Baguette et al. 2013; Gray et al. 2016) or ecosystem services such (Cimon-Morin et al. 2013; ten Brink et al. 2013). Nevertheless, there is one important drawback of the Portuguese EFT to mention: in contrast to the Brazilian EFT scheme the design of the Portuguese one does neither take PA categories and their different contribution to conservation nor the management of PAs into account (Santos et al. 2012), which reduces its potential to contribute to an effective biodiversity conservation.

8.3 Welfare implications of decentralization through EFT

The fiscal remuneration of ecological public functions has at least three welfare related effects, the realization of a) (supra-)national and b) local conservation interest.

Supra-national, EU level interest, regarding e.g. the Natura 2000 network, or nationally important conservation sites, such as national parks are reasonably better informed on the (supra-)national level where there are well-trained conservation experts with knowledge on the distribution of e.g. endangered species or important corridors for overarching habitat networks. For these (supra-)national PA designations, EFT compensate for the costs imposed to the local level and thus reduce negative external effects of higher government level conservation planning.

That municipalities have competencies to designate their own PA, however, opens a leeway for an incentive effect beyond mere compensation: per area transfers for PA raise the benefit-cost ratio for the designation of local PAs. Given the theoretical assumption that local decision makers designate PA where this is in (better) accordance with interests at the local level than a decision at a national level, EFT lead to more precise and locally differentiable preference satisfaction through decentralization in the decision where to protect nature. This effect is even observable from a macroeconomic perspective measured in the ratio of municipal to national PA. Although the value of the EFT of about 2.5-5 per cent of the Financial Equilibrium Fund is relatively low, it results in relatively high shares for some municipalities of up to third of total municipal revenues at its maximum (Santos et al. 2012). This may explain that for some municipalities the Portuguese EFT provides a strong financial incentive to designate an additional PA. Furthermore, the additional municipal PA increase the supply of underprovided local public goods such as biodiversity conservation with its potentially long spatial and temporal range spillover benefits. At the same time, however, there may be economies of scale in conservation (Armsworth et al. 2011). It is thus important to recognize that the introduction of EFT does not contradict or substitute but supplement

conservation competencies of (supra-)national bodies such as central planning agencies or the European authorities.

Thus, from the theory of fiscal federalism, EFT yields welfare gains through a) internalizing external effects of national conservation planning and b) decentralizing decisions on PA designations.

8.4 Motivations of local decision makers to designate protected areas

It is important to note that the econometric model assesses the movement of variables over time, which are partly (i.e. the numerator in our dependent variable of the ratio of municipal and national PA) the result of the decisions on the local level, and thereby observes results from an outcome variable perspective. The inference of a causal effect is thereby limited to such a quantitative perspective and may well be enhanced by further qualitative research that directly assesses the motivations of local decision makers. As introduced in the theoretical model section (see section 3), there can be a wide variety of actual reasons for designating municipal PA, among which the financial incentive inherent in EFT schemes may be found. However, we can observe a synchronicity in the events of introducing EFT and a rise in the ratio of municipal and national PA. Given our assumption that fiscal incentives may ease the designation of municipal PA, we would argue that, designation decisions for municipal PA have been eased by the introduction of EFT. However, a qualitative analysis of motivations of those municipalities that have actually designated more PA after the introduction of the EFT scheme and the (potential) behavioral changes of those municipalities benefitting most in terms of EFT allocations (see Santos et al., 2014, 2012 for a respective list of municipalities) could substantiate the results further and remains a task for future research.

9 Conclusion

Analyzing the effect of the 2007 introduction of EFT in Portugal, we provide quantitative evidence of an increase in the ratio of municipal and national PA numbers in the post-

intervention period. Comparing this observation to a simulated counterfactual time series, obtained by predicting pre-intervention correlations of socio-economic control variables with the outcome variable for the post-intervention period, we find a significant difference between counterfactual predictions and actual observations. We can observe a synchronicity of introducing EFT and the rise in the ratio of municipal and national PA, that is unlikely a consequence of random processes. Against the theoretical background, where we model how fiscal incentives may increase the designation of decentral PA, this observed decentralization effect has very likely been caused by the Portuguese EFT introduction.

Deducing implications from the theory of fiscal federalism, such decentralization leads to welfare gains since local preferences can better be taken into account and spatial conservation spill-over effects from municipal PAs are (partially) internalized. At the same time, such an additional decentralization effect does not exclude a centrally planned designation of protected areas of (supra-)national importance, as the municipal competencies do not substitute but supplement conservation competencies of (supra-)national bodies. For such central PA designations the EFT compensates for costs imposed to the local level. In terms of economic welfare, recognizing ecological public functions within fiscal transfers schemes, is thus likely increasing overall performance of the public sector.

The existence of municipal competencies for the designation of protected areas, however, can be seen a crucial element for the effective functioning of EFT, because without those municipal bodies would have no means to directly react to the incentive effect and increase the municipal supply of protected areas. Thus, as a response to the (inter-)national demands to protect biodiversity under limited budgets, introducing fiscal incentives through EFT will provide means to increase the likelihood of decentral conservation action without the need for additional expenditure only if decentral governments have corresponding conservation competencies.

Appendix

A 1 Summary statistics

Descriptive statistics

Statistic	N	Mean	St. Dev.	Min	Max
ratio municipal PA / national PA (PAratio)	20	0.173	0.117	0.036	0.375
valued added by agriculture (VAagr)	20	3,711,254,633	136,704,563	3,566,115,527	4,110,711,457
valued added by industry (VAind)	20	32,371,423,673	2,524,840,175	27,799,037,951	35,769,016,793
valued added by service (VAser)	20	96,957,621,027	9,520,538,122	77,956,243,299	108,038,023,839
GDP per capita (GDPcap)	20	14,603.360	896.900	12,383.830	15,636.750
population density (POPdens)	20	113.517	1.958	109.576	115.439
municipal environmental spending (ENVexp)	20	573,327.100	53,616.450	468,352.000	663,297.500
municipal environmental income (ENVinc)	20	210,387.300	47,144.360	134,958.000	304,035.400
environmental NGO members per 1,000 inhabitants (ENGOmem)	20	4.600	2.280	1	8

Sources: authors' calculations based on ICNF (2015), World Bank (2015), and INE (2015); monetary values are in constant € 2005 prices.

A 2 Time series of PA designation variables

Year	National PA area [ha]	Municipal PA area [ha]	Number of national PA	Number of municipal PA	Municipal PA based on 2008 competencies reform
1995	623,360	3,282	22	1	
1996	623,414	3,282	23	1	
1997	623,434	3,282	27	1	
1998	710,435	3,282	28	1	
1999	710,435	10,360	28	3	
2000	742,191	10,706	30	4	
2001	742,191	10,706	30	4	
2002	742,191	10,706	30	4	
2003	742,191	10,706	30	4	
2004	742,191	10,706	30	4	
2005	742,191	10,706	30	4	
2006	742,191	10,706	30	4	
2007	742,309	10,706	31	4	
2008	742,309	10,706	31	4	
2009	743,274	11,206	32	7	2
2010	743,274	13,418	32	11	2
2011	743,274	13,418	32	11	2
2012	743,274	13,418	32	11	2
2013	743,274	38,185	32	12	3
2014	743,274	38,185	32	12	3

Sources: authors' calculations based on ICNF (2015),

References

Andersson KP, Ostrom E (2008) Analyzing decentralized resource regimes from a polycentric perspective. Policy Sci 41:71–93. doi: 10.1007/s11077-007-9055-6

Armsworth PR, Cantú-Salazar L, Parnell M, et al. (2011) Management costs for small protected areas and economies of scale in habitat conservation. Biol Conserv 144:423–429. doi: 10.1016/j.biocon.2010.09.026

Ashenfelter O, Card D (1985) Using the Longitudinal Structure of Earnings to Estimate the Effect of Training Programs. Rev Econ Stat 67:648–660.

Athey S, Imbens GW (2015) Machine Learning Methods for Estimating Heterogeneous Causal Effects. arXiv:150401132 1–9.

Baguette M, Blanchet S, Legrand D, et al. (2013) Individual dispersal, landscape connectivity and ecological networks. Biol Rev 88:310–326. doi: 10.1111/brv.12000

Boadway R, Tremblay JF (2012) Reassessment of the Tiebout model. J Public Econ 96:1063–1078. doi: 10.1016/j.jpubeco.2011.01.002

Borge LE, Brueckner JK, Rattsø J (2014) Partial fiscal decentralization and demand responsiveness of the local public sector: Theory and evidence from Norway. J Urban Econ 80:153–163. doi: 10.1016/j.jue.2014.01.003

Borie M, Mathevet R, Letourneau A, et al. (2014) Exploring the Contribution of Fiscal Transfers to Protected Area Policy. Ecol Soc. doi: 10.5751/ES-05716-190109

Box GEP, Jenkins GM, Reinsel GC, Ljung GM (2016) Time Series Analysis : Forcasting and Control, 5th ed. Wiley, Hoboken, NJ

Box GEP, Tiao GC (1975) Intervention with Applications Analysis to Economic and Environmental Problems. J Am Stat Assoc 70:70–79.

Brennan G, Buchanan JM (1980) The Power to Tax: Analytic Foundations of a Fiscal Constitution. Liberty Fund, Indianapolis

Brodersen KH, Gallusser F, Koehler J, et al. (2015) Inferring causal impact using Bayesian structural time-series models. Ann Appl Stat 9:247–274. doi: 10.1214/14-AOAS788

Butchart SHM, Clarke M, Smith RJ, et al. (2015) Shortfalls and Solutions for Meeting National and Global Conservation Area Targets. Conserv Lett 8:329–337. doi: 10.1111/conl.12158

Cimon-Morin J, Darveau M, Poulin M (2013) Fostering synergies between ecosystem services and biodiversity in conservation planning: A review. Biol Conserv 166:144–154. doi: 10.1016/j.biocon.2013.06.023

Coase RH (1937) The Nature of the Firm. Economica 4:386–405.

Costa J da S, Carvalho A (2013) Yardstick Competition among Portuguese Municipalities The Case of Urban Property Tax (IMI).

Direção-Geral das Autarquias Locais (2015) Portal Autárquico - Municípios. http://www.portalautarquico.pt/pt-PT/financas-locais/transferencias/municipios/. Accessed 11 Nov 2015

Droste N, Lima GR, May PH, Ring I (2015) Ecological Fiscal Transfers in Brazil – incentivizing or compensating conservation? Pap. Present. 11th Int. Conf. Eur. Soc. Ecol. Econ.

EU (2015) Natura 2000 Barometer. http://ec.europa.eu/environment/nature/natura2000/barometer/index_en.htm. Accessed 25 Nov 2015

Evans D (2012) Building the European Union's Natura 2000 network. Nat Conserv 1:11. doi: 10.3897/natureconservation.1.1808

Faguet J-P (2014) Decentralization and Governance. World Dev 53:2–13. doi: 10.1016/j.worlddev.2013.01.002

Faguet JP (2004) Does decentralization increase government responsiveness to local needs? Evidence from Bolivia. J Public Econ 88:867–893. doi: 10.1016/S0047-2727(02)00185-8

Feld LP (2014) James Buchanan's theory of federalism: From fiscal equity to the ideal political order. Const Polit Econ 25:231–252. doi: 10.1007/s10602-014-9168-9

Gaston KJ, Jackson SF, Can u-Salazar L, Cruz-P on G (2008) The Ecological Performance of Protected Areas. Annu Rev Ecol Evol Syst 39:93–113. doi: 10.1146/annurev.ecolsys.39.110707.173529

George EI, McCulloch RE (1997) Approaches for bayesian variable selection. Stat Sin 7:339–373. doi: 10.1.1.211.4871

Gray CL, Hill SLL, Newbold T, et al. (2016) Local biodiversity is higher inside than outside terrestrial protected areas worldwide. Nat Commun 7:12306. doi: 10.1038/ncomms12306

Grieg-Gran M (2000) Fiscal incentives for biodiversity conservation: The ICMS Ecológico in Brazil. International Institute for Environment and Development, London

Heckman JJ (2008) Econometric causality. Int Stat Rev 76:1–27.

Hyndman RJ (2014) Fitting models to short time series. In: Hyndsight. http://robjhyndman.com/hyndsight/short-time-series/. Accessed 26 Nov 2015

Hyndman RJ, Kostenko A V. (2007) Minimum Sample Size Requirements. foresight 12–15.

Inman RP, Rubinfeld DL (1997) Rethinking Federalism. J Econ Perspect 1:43–64. doi: 10.3817/0694100003

Instituto da Conservação da Natureza e das Florestas (ICNF) (2015) Áreas Protegidas.

http://www.icnf.pt/portal/ap. Accessed 6 Feb 2015
Instituto Nacional de Estatística (INE) (2015) Portal de Estastística. http://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_main. Accessed 6 Feb 2015
Irawan S, Tacconi L, Ring I (2014) Designing intergovernmental fiscal transfers for conservation: The case of REDD+ revenue distribution to local governments in Indonesia. Land use policy 36:47–59. doi: 10.1016/j.landusepol.2013.07.001
Köllner T, Schelske O, Seidl I (2002) Integrating biodiversity into intergovernmental fiscal transfers based on cantonal benchmarking: a Swiss case study. Basic Appl Ecol 3:381–391. doi: 10.1078/1439-1791-00104
Kotchen MJ, Reiling SD (2000) Environmental attitudes, motivations, and contingent valuation of nonuse values: A case study involving endangered species. Ecol Econ 32:93–107. doi: 10.1016/S0921-8009(99)00069-5
Kumar S, Managi S (2009) Compensation for environmental services and intergovernmental fiscal transfers: The case of India. Ecol Econ 68:3052–3059. doi: 10.1016/j.ecolecon.2009.07.009
List JA, Bulte EH, Shogren JF (2002) "Beggar thy neighbor:" Testing for free riding in state-level endangered species expenditures. Public Choice 111:303–315. doi: 10.1023/A:1014947110729
Loureiro W (2002) Contribuição do ICMS Ecológico à Conservação da Biodiversidade no Estado do Paraná. Universidade Federal do Paraná, Curitiba
Loureiro W, Pinto MA, Motta MNJ (2008) Legislação atualizada do ICMS Ecológico por Biodiversidade. Curitiba
May PH, Veiga Neto F, Denardin V, Loureiro W (2002) Using fiscal instruments to encourage conservation: Municipal responses to the "ecological"value-added tax in Paraná and Minas Gerais, Brazil. In: Pagiola S, Bishop J, Landell-Mills N (eds) Sell. For. Environ. Serv. Mark. Mech. Conserv. Dev. Earthscan, London, pp 173–199
Meyer BD (1995) Natural und Quasi-experiments in Economics. J Bus Econ Stat 13:151–161.
Millennium Ecosystem Assessment (2005) Ecosystems and Human Well-being: Synthesis. Island Press, Washington, D.C.
Mumbunan S (2011) Ecological fiscal transfers in Indonesia. University Leipzig
Musgrave RM (1959) The Theory of Public Finance: A Study in Public Economy. McGraw-Hill, New York
Nolon JR (2005) Comparative Land Use Law: Patterns of Sustainability. The Urban Lawyer 37:807–852.
Oates WE (2005) Toward A Second-Generation Theory of Fiscal Federalism. Int Tax Public Financ 12:349–373.
Oates WE (1972) Fiscal Federalism. Harcourt Brace Jovanovich, New York
Ojea E, Loureiro ML (2007) Altruistic, egoistic and biospheric values in willingness to pay (WTP) for wildlife. Ecol Econ 63:807–814. doi: 10.1016/j.ecolecon.2007.02.003
Olson M (1969) The Principle of "Fiscal Equivalence": The Division of Responsibilities among Different Levels of Government. Am Econ Rev 59:479–487. doi: 10.1126/science.151.3712.867-a
Ostrom E (1990) Governing the commons : the evolution of institutions for collective action. Cambridge Univ. Press, Cambridge
Perrings C, Gadgil M (2003) Conserving biodiversity: Reconciling local and global public benefits. In: Kaul I, Conceicao P, Le Goulven K, Mendoza RL (eds) Provid. Glob. Public Goods Manag. Glob. Oxford University Press, Oxford, pp 532–555
Qian Y, Weingast BR (1997) Federalism as a Commitment to Preserving Market Incentives. J Econ Perspect 11:83–92.
R Development Core Team (2016) R: A Language and Environment for Statistical Computing.
Ring I (2002) Ecological public functions and fiscal equalisation at the local level in Germany. Ecol Econ 42:415–427. doi: 10.1016/S0921-8009(02)00124-6
Ring I (2008a) Integrating local ecological services into intergovernmental fiscal transfers: The case of the ecological ICMS in Brazil. Land use policy 25:485–497. doi: 10.1016/S0921-8009(02)00124-6
Ring I (2008b) Biodiversity governance: Adjusting local costs and global benefits. In: Sikor T (ed) Public Priv. Nat. Resour. Gov. a False Dichotomy? Earthscan, London, pp 107–126
Ring I, May PH, Loureiro W, et al. (2011) Ecological fiscal transfers. In: Ring I, Schlaack CS (eds) Instrum. Mix. Biodivers. Policies. POLICYMIX Rep. No. 2/2011. Helmholtz Centre for Environmental Research - UFZ, Leipzig, pp 98–118
Rubinchik-Pessach A (2005) Can decentralization be beneficial? J Public Econ 89:1231–1249. doi: 10.1016/j.jpubeco.2003.11.005
Samuelson PA (1954) The Pure Theory of Public Expenditure. Rev Econ Stat 36:387–389.
Samuelson PA (1955) Diagrammatic exposition of a theory of public expenditure. Rev Econ Stat 37:350–356. doi: 10.2307/1925849
Santos R, Antunes P, Ring I, Clemente P (2015) Engaging Local Private and Public Actors in Biodiversity Conservation: The role of Agri-Environmental schemes and Ecological fiscal transfers. Environ Policy Gov 25:83–96. doi: 10.1002/eet.1661
Santos R, Ring I, Antunes P, et al. (2014) Ecological Fiscal Transfers – a policy response to local conservation

challenges. In: Henle K, Potts S, Kunin W, et al. (eds) Scaling Ecol. Biodivers. Conserv. Pensoft, Sofia, pp 124–127
Santos R, Ring I, Antunes P, Clemente P (2012) Fiscal transfers for biodiversity conservation: The Portuguese Local Finances Law. Land use policy 29:261–273. doi: 10.1016/j.landusepol.2011.06.001
Sauquet A, Marchand S, Féres J (2014) Protected areas, local governments, and strategic interactions: The case of the ICMS-Ecológico in the Brazilian state of Paraná. Ecol Econ 107:249–258. doi: 10.1016/j.ecolecon.2014.09.008
Schröter-Schlaack C, Ring I, Koellner T, et al. (2014) Intergovernmental fiscal transfers to support local conservation action in Europe. Z Wirtschgeogr 58:98–114.
Scott SL, Varian H (2014) Predicting the Present with Bayesian Structural Time Series. Int J Math Model Optim 5:4–23. doi: 10.1504/IJMMNO.2014.059942
Sen A (1977) Rational Fools: A Critique of the Behavioral Foundations of Economic Theory. Philos Public Aff 6:317–344. doi: 10.2307/2264946
Simon H (1955) A behavioral model of rational choice. Q J Econ 69:99–118.
Simonton DK (1977) Cross - Sectional Time - Series Experiments : Some Suggested Statistical Analyses. Psychol Bull 84:489-S02.
Smith HJM, Revell KD (2016) Micro-Incentives and Municipal Behavior: Political Decentralization and Fiscal Federalism in Argentina and Mexico. World Dev 77:231–248. doi: 10.1016/j.worlddev.2015.08.018
Smith RJ, Veríssimo D, Leader-Williams N, et al. (2009) Let the locals lead. Nature 462:280–281.
Spash CL (2006) Non-Economic Motivation for Contingent Values: Rights and Attitudinal Beliefs in the Willingness To Pay for Environmental Improvements. Land Econ 82:602–622. doi: 10.3368/le.82.4.602
Spash CL, Urama K, Burton R, et al. (2009) Motives behind willingness to pay for improving biodiversity in a water ecosystem: Economics, ethics and social psychology. Ecol Econ 68:955–964. doi: 10.1016/j.ecolecon.2006.09.013
Street A, Murray TA, Blitzer JB, Patel RS (2015) Estimating voter registration deadline effects with web search data. Polit Anal 23:225–241. doi: 10.1093/pan/mpv002
TEEB (2010) The Economics of Ecosystems and Biodiversity: Mainstreaming the Economics of Nature: A synthesis of the approach, conclusions and recommendations of TEEB.
ten Brink P, Bassi S, Badura T, et al. (2013) Economic benefits of the Natura 2000 Network. Synthesis Report. doi: 10.2779/41957
Terman JN, Feiock RC (2014) Improving Outcomes in Fiscal Federalism: Local Political Leadership and Administrative Capacity. J Public Adm Res Theory. doi: 10.1093/jopart/muu027
Thiel A (2015) Constitutional state structure and scalar re-organization of natural resource governance: The transformation of polycentric water governance in Spain, Portugal and Germany. Land use policy 45:176–188. doi: 10.1016/j.landusepol.2015.01.012
Tiebout CM (1956) A Pure Theory of Local Expenditures. J Polit Econ 64:416–424.
Vatn A (2007) Institutions and the Environment. Edward Elgar, Cheltenham
Vogel J (1997) The Successful Use of Economic Instruments to Foster Sustainable Use of Biological diversity: Six Case Studies from Latin America and the Caribbean. Biopolicy J 2:1–44.
von Hayek FK (1945) The Use of Knowledge in Society. Am Econ Rev 35:519–530.
Weingast BR (2009) Second generation fiscal federalism: The implications of fiscal incentives. J Urban Econ 65:279–293.
Weingast BR (2014) Second Generation Fiscal Federalism: Political Aspects of Decentralization and Economic Development. World Dev 53:14–25. doi: 10.1016/j.worlddev.2013.01.003
Williams RC (2012) Growing state-federal conflicts in environmental policy: The role of market-based regulation. J Public Econ 96:1092–1099. doi: 10.1016/j.jpubeco.2011.08.003
World Bank (2015) World Development Indicators| World DataBank. http://databank.worldbank.org/data/reports.aspx?source=2&country=PRT&series=&period=#. Accessed 12 Nov 2015
Wu J (2014) Public open-space conservation under a budget constraint. J Public Econ 111:96–101. doi: 10.1016/j.jpubeco.2013.12.008
Zodrow GR, Mieszkowski P (1986) Pigou, Tiebout, property taxation, and the underprovision of local public goods. J Urban Econ 19:356–370. doi: 10.1016/0094-1190(86)90048-3