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Uncertainty and the preferred instrument for fiscal discipline under multitier government

Wouter VAN DER WIELEN

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Uncertainty and the Preferred Instrument for Fiscal Discipline under Multitier Government*

Wouter van der Wielen†
KU Leuven

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Abstract

This paper assesses the impact of budgetary uncertainty on the optimum instrument for fiscal discipline. In addition to exogenous uncertainty, with respect to both the savings and damages of the public deficit, the model accommodates for externalities as a result of a multitier government structure. Hence, the model approximates fiscal discipline measures within federations and especially within a monetary union. Alternative to the frequently proposed fiscal rule constraining the magnitude of the public deficit, the paper sets forth a price control (i.e. a penalty) as a policy instrument. The preferred instrument for fiscal discipline is found to be dependent on the slopes of the marginal savings and damage curves, the savings uncertainty and the correlation between uncertainty in savings and damage as well as between member states' savings shocks. In particular, strongly asymmetric shocks to budgetary policy run a borrowing constraint undesirable. The latter is stressed as exceptionally disturbing as EMU member states are still considered to be asymmetric in their stochastics, while stressing borrowing constraints as the principal instrument for fiscal discipline.

Keywords: Fiscal discipline, fiscal rules, borrowing constraints, budgetary uncertainty

JEL codes: H10, H61, H62, D81, E62

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†KU Leuven, Center for Economic Studies, Naamsestraat 69, 3000 Leuven, Belgium. Email: *wouter.vanderwielen@kuleuven.be*. Telephone: +32/16326655

1 Introduction

A consensus exists on the necessity for fiscal measures both in the short-run and the long-run to safeguard the stability of public finances, while at the same time not hampering economic recovery. A frequently proposed way of achieving fiscal discipline is to implement fiscal rules or public borrowing constraints. For instance, the golden rule of public finance adopted in the past in Germany and the UK required running an overall balanced budget while allowing for debt-financed investments. More recently, the Fiscal Compact further strengthened the structural balance requirements of the medium-term objectives imposed on EMU Member States.[1]

In the same vein, federal member states, such as Belgium, are confronted with the challenge to allocate the required effort among their regions. A federal government is not only concerned with overall sustainability of the federal state, but is also inclined to prevent lower levels of government from running deficits disadvantageous to other member states. To preclude externalities and avert time-inconsistent behavior on the part of the federal government itself, regional borrowing constraints are on the rise as well.

Obviously, quantitative borrowing constraints are just one possible control instrument to achieve fiscal discipline. In order to cast light on what type of instrument is optimal in practice, it is important to take the uncertainty accompanying fiscal policy into consideration. For instance, the benefit of an additional unit of austerity is often only partly revealed ex ante, although crucial in the decision process. Notwithstanding its importance, budgetary uncertainty's impact on disciplinary policy has, so far, been left untouched in the literature.

Therefore, the purpose of this paper is to assess federal policy makers' decisions to achieve fiscal discipline among its member states using a model incorporating the uncertainty of both savings and damages of the deficit. Specifically, the comparative advantage of a price instrument (i.e. a pecuniary penalty per unit of deficit) over a quantitative borrowing constraint is derived in function of the budgetary uncertainty. Consequently, a clear picture is provided of the impact of budgetary uncertainty on the preferred measure for fiscal discipline in federal countries as well as the case of supranational oversight of the members of a monetary union.

Using a theoretical model specifying the stochastic regional savings of one additional unit of deficit and the accompanying stochastic federal damages, the preferred instrument for fiscal discipline is found to be dependent on the slopes of the marginal savings and damage curves, the savings uncertainty and the correlation between uncertainty in savings and damage. Moreover, the comparative advantage depends on the correlation between member states' savings shocks as well. In particular, strongly asymmetric shocks to budgetary policy

[1] Building on the fiscal provisions from the Stability and Growth Pact and the Six-Pack, the main budgetary outcome of the Fiscal Compact (formally, the Treaty on Stability, Coordination and Governance in the EMU) is a reduction of the medium-term objective for a member state's structural deficit to 0.5 per cent of GDP in case the country's public debt exceeds the 60 per cent debt threshold.

runs a borrowing constraint undesirable. Therefore, the asymmetry in shocks among (EMU) member states is found to prevent a quantity constraint from functioning efficiently vis-à-vis a penalty-based system.

The next section provides a basis for the contentious forces underlying disciplinary considerations and thus the marginal savings and damage curves of one additional unit of deficit. Moreover, it presents the control instruments considered. Section 3 extends this framework by exploring the uncertainty accompanying the savings and damage of a public deficit. It comprises the core model of this paper, the derivation of the comparative advantages of the suggested policy measures and a thorough discussion of the resulting policy implications for both a federal and a supranational setting. Finally, section 4 provides some concluding remarks.

2 Controlling Fiscal Indiscipline

2.1 Setup

In the fiscal control problem set out below the deficit, d, will be the control variable. After all, the variable to be regulated in practice is most often the budget balance. More specifically, structural fiscal discipline measures specify their goals in terms of a maximum amount to borrow. Nonetheless, the corresponding austerity measures (i.e. deficit reductions) can be easily derived from the model too.

Consider a federation with N member states indexed $n \in \{1, ..., N\}$. As a result, $\mathbf{d_t} = (d_{1,t}, ..., d_{N,t})$ will be an N-vector comprising all member states' deficits at time t. Assume that regional governments only take into account the consequences of their fiscal policy on their own state and ignore spillovers, then the regional savings of a deficit in state n at time t can be represented as $s_{n,t}(d_{n,t})$.

Next, take a second-order Taylor approximation of the member states' savings functions around $\hat{\mathbf{d}}_{\mathbf{t}} = (\hat{d}_{1,t}, ..., \hat{d}_{N,t})$:

$$\begin{cases} s_{1,t}(d_{1,t}) \cong s_{1,t}(\hat{d}_{1,t}) + \frac{\partial}{\partial \hat{d}_{1,t}} s_{1,t}(\hat{d}_{1,t}) \cdot (d_{1,t} - \hat{d}_{1,t}) + \frac{1}{2} \frac{\partial^2}{\partial \hat{d}_{1,t}^2} s_{1,t}(\hat{d}_{1,t}) \cdot (d_{1,t} - \hat{d}_{1,t})^2 \\ ... \\ s_{N,t}(d_{N,t}) \cong s_{N,t}(\hat{d}_{N,t}) + \frac{\partial}{\partial \hat{d}_{N,t}} s_{N,t}(\hat{d}_{N,t}) \cdot (d_{N,t} - \hat{d}_{N,t}) + \frac{1}{2} \frac{\partial^2}{\partial \hat{d}_{N,t}^2} s_{N,t}(\hat{d}_{N,t}) \cdot (d_{N,t} - \hat{d}_{N,t})^2 \end{cases} \tag{1}$$

Hence, the marginal savings functions can be written as follows:

$$\begin{cases} \frac{\partial}{\partial d_{1,t}} s_{1,t}(d_{1,t}) \cong \frac{\partial}{\partial \hat{d}_{1,t}} s_{1,t}(\hat{d}_{1,t}) + \frac{\partial^2}{\partial \hat{d}_{1,t}^2} s_{1,t}(\hat{d}_{1,t}) \cdot (d_{1,t} - \hat{d}_{1,t}) \\ ... \\ \frac{\partial}{\partial d_{N,t}} s_{N,t}(d_{N,t}) \cong \frac{\partial}{\partial \hat{d}_{N,t}} s_{N,t}(\hat{d}_{N,t}) + \frac{\partial^2}{\partial \hat{d}_{N,t}^2} s_{N,t}(\hat{d}_{N,t}) \cdot (d_{N,t} - \hat{d}_{N,t}). \end{cases} \tag{2}$$

The *marginal savings functions* convey the marginal savings of one additional unit of deficit for each of the N member states. Examples of such savings are widespread: e.g. deficits provide leeway to reduce the distortions as a result of (non-smoothed) taxation and the distributive effects in the presence of liquidity constrained agents. As the savings for the member state of one additional unit of deficit will therefore increase as the fiscal deficit is reduced further, the marginal savings curves are downward sloping: $\frac{\partial^2}{\partial d_{n,t}^2} s_{n,t}(d_{n,t}) < 0$.

The damages of a deficit, on the other hand, ought to be mainly valued at the federal level of government. In particular, one member states' unsustainability might be borne by other members in case of a default or a bailout in a federation. Therefore, a contradiction between the interests of different agents occurs. While the member states only take their individual regional concerns (and hence might burden other members) into account, the higher level of government will be concerned with possible externalities. Therefore, the *marginal damage function* entails the damage to the federation as a whole when a member state runs one additional unit of deficit. Thus, it represents the marginal benefits of one additional unit of deficit reduction to the federation as a whole, including both sustainability concerns and other social benefits or costs of reducing the deficit not taken into account by the states themselves.

Formally, the objective function is represented as $D_t(\mathbf{d_t})$:

$$D_t(\mathbf{d_t}) \cong D_t(\mathbf{\hat{d}_t}) + \nabla D_t(\mathbf{\hat{d}_t}) \cdot (\mathbf{d_t} - \mathbf{\hat{d}_t}) + \frac{1}{2}(\mathbf{d_t} - \mathbf{\hat{d}_t})^T \cdot H(D_t)_{nm}(\mathbf{\hat{d}_t}) \cdot (\mathbf{d_t} - \mathbf{\hat{d}_t}) \quad (3)$$

linking vector $\mathbf{d_t}$ at time t to the social benefits of reduction, with $\nabla D_t(\mathbf{\hat{d}_t})$ the gradient, $H(D_t)_{nm}(\mathbf{\hat{d}_t})$ the Hessian of the scalar function and $m \in \{1, ..., N\}$. By means of clarification, both are given in full in appendix A.1.

Consequently, the marginal damage of a deficit in state n at time t is expressed as follows,[2]

$$\frac{\partial}{\partial d_{n,t}} D_t(\mathbf{d_t}) \cong \frac{\partial}{\partial \hat{d}_{n,t}} D_t(\mathbf{\hat{d}_t}) + \nabla_{d_{n,t}} D_t(\mathbf{\hat{d}_t}) \cdot (\mathbf{d_t} - \mathbf{\hat{d}_t}) \quad (4)$$

where $\nabla_{d_{n,t}} D_t(\mathbf{\hat{d}_t})$ is the nth row of the Hessian of D_t at $\mathbf{\hat{d}_t}$. The union-wide marginal damage is presumed to increase as the deficit increases: $\frac{\partial^2}{\partial d_{n,t}^2} D_t(\mathbf{d_t}) > 0$. The latter is in accordance with the empirical findings indicating increased union wide interest rates as fiscal balances worsen and a higher debt stock is accumulated.[3]

The aforementioned can be graphically illustrated as it is in figure 1. The figure portrays the marginal damage (MD) and marginal savings (MS) of one

[2] The detailed derivation is included in appendix A.2

[3] The marginal damage function might be further differentiated according to for instance member states' membership of the core or periphery of the union or federation. That way the Southern European member states' sustainability concerns, distinct from those of the core, can be taken into account separately via differing slopes. The resulting conclusions for disciplinary policy instruments of such differentiation can be inferred from lemma 1 in section 3.2. As notation is already burdensome, the extension is left out without loss of generality.

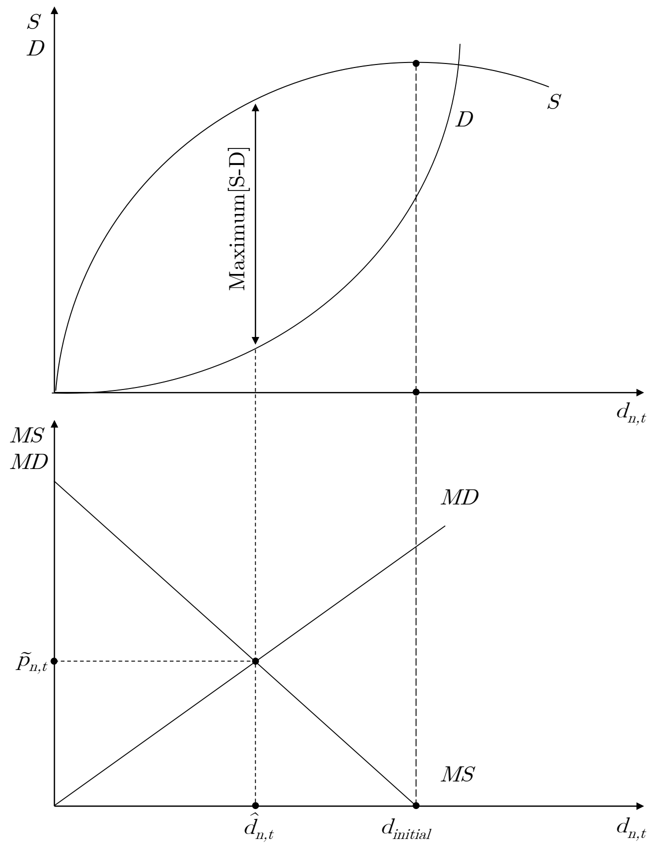

Figure 1: The (Marginal) Savings and Damages of the Regional Deficit for the Federal Regulator

additional unit of deficit, with the fiscal deficit and the respective (marginal) damages and savings of deficit reduction as axes.[4]

The functional properties are assumed to be as follows:

$$\frac{\partial}{\partial d_{n,t}} s_{n,t}(d_{n,t}) > \frac{\partial}{\partial d_{n,t}} D_t(\mathbf{d_t}) \tag{5}$$

if $d_{n,t}$ small enough. Thus, as commonly perceived, when larger and larger budget surpluses are accrued, limiting fiscal policy becomes undesirable since advisable public expenditures (e.g. social security, redistribution, public infrastructure and services) might be hampered. On the other end of the spectrum,

[4]Note that the maximum aggregate savings needs not coincide with the initially projected deficit as depicted in figure 1. The marginal costs of a deficit reduction may just as well be non-zero from the start.

for $d_{n,t}$ sufficiently large:

$$\frac{\partial}{\partial d_{n,t}} s_{n,t}(d_{n,t}) < \frac{\partial}{\partial d_{n,t}} D_t(\mathbf{d_t}). \tag{6}$$

As the marginal benefits of reducing the public deficit exceed the marginal costs of doing so, there is a need for fiscal discipline. To this end, two instruments to restrict borrowings will be introduced in the next subsection.

2.2 Policy Instruments

Borrowing constraints are often proposed and implemented under multitier government as a measure to harden soft budget constraints (see e.g. Rodden et al., 2003). To assign **a quantitative borrowing constraint** to each member state, the federal authority solves

$$\underset{\mathbf{d_t}}{\text{Max}} \sum_{t=1}^{T} \beta^t \left[\sum_{n=1}^{N} s_{n,t}(d_{n,t}) - D_t(\mathbf{d_t}) \right]. \tag{7}$$

The regulator will enforce deficit levels in order to maximize the difference between the member state specific savings of running deficits and the overall damages to the federation of doing so. This optimization will result in $\hat{\mathbf{d}}_{\mathbf{t}}$, a N-vector comprising a deficit rule $\hat{d}_{n,t}$ for each region n, satisfying $\frac{\partial}{\partial \hat{d}_{n,t}} s_{n,t}(\hat{d}_{n,t}) = \frac{\partial}{\partial \hat{d}_{n,t}} D_t(\hat{\mathbf{d}}_{\mathbf{t}})$.[5]

As illustrated in figure 1, deficits exceeding level $\hat{\mathbf{d}}_{\mathbf{t}}$ provide room for improvement. In that case, the damage of the deficit outweigh its savings and thus reducing the deficit is preferred. Points to the left of $\hat{\mathbf{d}}_{\mathbf{t}}$, would impose relatively too high savings for an additional unit of deficit and would encourage running a higher deficit. Only where the marginal savings and marginal damages are equalized, and thus the difference between the savings and the overall damages of the deficit is maximized, a borrowing constraint would be optimal.

Alternatively, the regulator could set **a pecuniary penalty** to be paid per unit of deficit. Pricing the public deficit has, however, been passed over in practice due to its pro-cyclical nature, for the disciplinary fee itself puts additional strain on the deteriorated budget. Nonetheless, a price or penalty's procyclicality can be easily overcome by lagging the payment. Moreover, as shown below, a penalty is not without use. In the deterministic model considered so far, there is, however, no difference in the outcomes achieved via both instruments.

In case a price control $\tilde{p}_{n,t}$ is used, marginal damages are fixed such that marginal savings will not exceed this level when the states choose their deficit level. Consequently, member state n will adjust its path of future fiscal balances

[5] If the regulatory authority would be indifferent between an additional unit of austerity in member state i and member state j, a uniform borrowing constraint for all countries could be set. From an economic efficiency point of view this would be a strong restriction on policy. Accordingly, the model is kept more general by respecting heterogeneity and keeping this as a subset.

$\{d_{n,t}\}$ to the respective level $h_{n,t}(\tilde{p}_{n,t})$, given the $\tilde{p}_{n,t}$ chosen by the federal authority. In particular, the price constraints $\mathbf{\tilde{p}_t} = (\tilde{p}_{1,t}, ..., \tilde{p}_{N,t})$ enforced by the federal government are the result of the following optimization problem:[6]

$$\underset{\mathbf{p}_t}{\text{Max}} \sum_{t=1}^{T} \beta^t \left[\sum_{n=1}^{N} s_{n,t}(h_{n,t}(p_{n,t})) - D_t(\mathbf{h_t}(\mathbf{p_t})) \right], \tag{8}$$

implying

$$\frac{\partial}{\partial h_{n,t}} s_{n,t}(h_{n,t}(\tilde{p}_{n,t})) \cdot \frac{\partial}{\partial \tilde{p}_{n,t}} h_{n,t}(\tilde{p}_{n,t}) = \frac{\partial}{\partial h_{n,t}} D_t(\mathbf{h_t}(\mathbf{\tilde{p}_t})) \cdot \frac{\partial}{\partial \tilde{p}_{n,t}} h_{n,t}(\tilde{p}_{n,t}) \tag{9}$$

However, using the marginal savings equations (2) and the fact that the price will equal the marginal savings in equilibrium, it is straightforward to show that $h_{n,t}(\tilde{p}_{n,t}) \cong \hat{d}_{n,t}$ and both policy instruments lead to the same outcome in a deterministic setting. A result that is also inferred easily from figure 1.

3 Budgetary Uncertainty

3.1 Simultaneous and Asymmetric Uncertainty

There is a considerable amount of uncertainty in the ex ante expected savings and damages of the deficit. Budgetary uncertainty results from a multiplicity of causes.

The savings for the member state of an additional unit of deficit, for example, depend on the desirability of the new public expenditures and the impact on output. These are dependent on the size of the fiscal multiplier, which itself is ambiguous and determined in its value by other variables (e.g. the marginal propensity to consume). In general, the higher the multiplier is, the more desirable the deficit will be. Similarly, the distributive impact of austerity depends on the measures taken. Moreover, shifts in distortionary taxes will bring about an excess burden driven by uncertain microeconomic factors. In its turn, the electoral cycle and process will determine the perceived political costs of reducing the deficit and is subject to the woes of politicians. Consequently, given the member states' uncertainty concerning the savings of the deficit ($\theta_{n,t}$), the ex post realizations may differ greatly from their ex ante expectations.

The federal government's uncertainty with respect to the damages of an additional unit of deficit (η_t) results from several, mainly macroeconomic, factors. Besides possible uncertainty about future budgetary policy (i.e. after current policy makers' term), the impact on sustainability is uncertain due to the limited knowledge of future economic growth, inflation and interest rates. The required adjustments in future primary balances to redirect policy to a sustainable path might, for example, affect interest rates. Furthermore, when aiming

[6] Parallel to footnote 5, differentiating the price to be paid across member states according to regional differences in the benefits of deficit reduction accommodates a more efficient austerity program, although differentiation is not necessarily perceived justifiable based on non-economical reasons.

at stabilizing the debt level there are strict preconditions for the interest and growth rates in order for the debt to converge. More recently, the role of financial markets' expectations in determining the possibility of convergence has been emphasized as well. Financial markets might create a self-fulfilling prophecy of unsustainability via their influence on the interest burden. Irrespective of such self-fulfilling prophecies, financial markets' expectations can have a major influence on the rates of return in turbulent times.

Moreover, there is *simultaneity* in the uncertainty experienced by both the regional and the federal governments as the ex post realizations of the savings and damages are not determined independently from each other. For instance, the variables underlying future economic growth (e.g. the fiscal multiplier) influence both the savings and the sustainability considerations. Consequently, the correlation between the disturbance terms of the regional savings and the federally evaluated damages, introduced below, will be assumed to be different from zero.

It is worth noticing that a significant part of the above-mentioned uncertainty is shaped by the business cycle. Implementing a borrowing constraint based on the cyclically adjusted budget balance (CABB), as often the case in practice, largely eliminates this component of uncertainty from both costs and benefits. Although the methodology to determine the cyclical component has been found to lack soundness at times, using the CABB governments are not held accountable for the budgetary consequences of the business cycle. Nonetheless, other sources of uncertainty remain. Non-cyclical, non-discretionary incidences such as socio-demographic changes are some.

The degree and type of uncertainty furthermore *depend on the level of government* and vary across the same level. The uncertainty resulting from externalities is an especially decisive factor at the higher level of government. As mentioned above, federal governments take account of the negative spillovers from expected unsustainability in their objective function. This is a consideration subject to considerable uncertainty as it is hard to inventory all possible positive and negative spillovers. Therefore, the federal objective function is characterized by a disturbance term (η_t) incorporating this overall uncertainty distinguishable form the regional uncertainty ($\theta_{n,t}$). Likewise, there may be stochastic differences *across the same level* of government due to varying degrees of stability in member states' policy environment.[7] Accordingly, disturbance terms $\theta_{n,t}$ are indexed by member state.

In any case, uncertainty is very likely to differ at both levels and across different units at the same level. The uncertainty in the budgetary decision process, moreover, is crucial for the optimality of the final outcome. Hence, in what follows, I study the influence of budgetary uncertainty on the optimum instrument for fiscal discipline.

[7]The principle of subsidiarity delegating responsibilities downwards as a result of the differences in the awareness concerning the social desirability of a policy is rooted in those interregional differences.

3.2 The Stochastic Model

Now, again consider a federation with N member states indexed $n \in \{1, ..., N\}$. As before, $\mathbf{d_t} = (d_{1,t}, ..., d_{N,t})$ will be an N-vector comprising all member states' deficits at time t. Yet, the *stochastic* relation linking the prevailing deficit $d_{n,t}$ in state n at time t to its costs of reduction will be $c_{n,t}(d_{n,t}, \theta_{n,t})$, where $\theta_{n,t}$ is the disturbance term. This random variable is unobserved and unknown ex ante.

As in Weitzman's (1974), it is presumed that the random term characterizing uncertainty is sufficiently small to justify second-order Taylor approximations of generalized total savings and damage functions. Therefore, using a second-order Taylor approximation of the member states' savings functions around $\hat{\mathbf{d}}_\mathbf{t} = (\hat{d}_{1,t}, ..., \hat{d}_{N,t})$ and splitting the marginal savings at $\hat{d}_{n,t}$ into a deterministic component (i.e. its expectation; represented by the expectations operator $\mathbb{E}[\bullet]$) and a stochastic component resulting from budgetary uncertainty,

$$\alpha_{n,t}(\theta_{n,t}) \equiv \frac{\partial}{\partial \hat{d}_{n,t}} s_{n,t}(\hat{d}_{n,t}, \theta_{n,t}) - \mathbb{E}\left[\frac{\partial}{\partial \hat{d}_{n,t}} s_{n,t}(\hat{d}_{n,t}, \theta_{n,t})\right]. \tag{10}$$

the savings for the member state of one additional unit of deficit can be written as follows:

$$\begin{cases} \frac{\partial}{\partial d_{1,t}} s_{1,t}(d_{1,t}, \theta_{1,t}) \cong \left(\mathbb{E}\Big[\frac{\partial}{\partial \hat{d}_{1,t}} s_{1,t}(\hat{d}_{1,t}, \theta_{1,t})\Big] + \alpha_{1,t}(\theta_{1,t})\right) + \frac{\partial^2}{\partial \hat{d}_{1,t}^2} s_{1,t}(\hat{d}_{1,t}, \theta_{1,t}) \cdot (d_{1,t} - \hat{d}_{1,t}) \\ \dots \\ \frac{\partial}{\partial d_{N,t}} s_{N,t}(d_{N,t}, \theta_{N,t}) \cong \left(\mathbb{E}\Big[\frac{\partial}{\partial \hat{d}_{N,t}} s_{N,t}(\hat{d}_{N,t}, \theta_{N,t})\Big] + \alpha_{N,t}(\theta_{N,t})\right) + \frac{\partial^2}{\partial \hat{d}_{N,t}^2} s_{N,t}(\hat{d}_{N,t}, \theta_{N,t}) \cdot (d_{N,t} - \hat{d}_{N,t}). \end{cases} \tag{11}$$

The stochastic component is assumed to be distributed such that its expected value is zero: $\mathbb{E}[\alpha_{n,t}(\theta_{n,t})] = 0$. Moreover, for simplicity, an unexpected shock is assumed to be restricted to shifts in the marginal curves, leaving the functions' curvature unchanged:

$$\frac{\partial^2}{\partial \hat{d}_{n,t}^2} s_{n,t}(\hat{d}_{n,t}, \theta_{n,t}) \equiv \mathbb{E}\left[\frac{\partial^2}{\partial \hat{d}_{n,t}^2} s_{n,t}(\hat{d}_{n,t}, \theta_{n,t})\right]. \tag{12}$$

As noted in section 3.1, the savings uncertainty $\theta_{n,t}$ is asymmetric among regions. The damages of a deficit, on the other hand, ought to be mainly valued at the federal level of government. Hence, in addition to uncertainty on regional savings, there is uncertainty on the federal damages of a deficit. Consequently, the marginal damage is expressed as follows,

$$\frac{\partial}{\partial d_{n,t}} D_t(\mathbf{d_t}, \eta_t) \cong \left(\mathbb{E}\Big[\frac{\partial}{\partial \hat{d}_{n,t}} D_t(\hat{\mathbf{d}}_\mathbf{t}, \eta_t)\Big] + \gamma_t(\eta_t)\right) + \nabla_{d_{n,t}} D_t(\hat{\mathbf{d}}_\mathbf{t}, \eta_t) \cdot (\mathbf{d_t} - \hat{\mathbf{d}}_\mathbf{t}) \tag{13}$$

with

$$\gamma_t(\eta_t) \equiv \frac{\partial}{\partial \hat{d}_{n,t}} D_t(\hat{\mathbf{d}}_\mathbf{t}, \eta_t) - \mathbb{E}\left[\frac{\partial}{\partial \hat{d}_{n,t}} D_t(\hat{\mathbf{d}}_\mathbf{t}, \eta_t)\right] \quad \text{and} \quad \mathbb{E}[\gamma_t(\eta_t)] = 0. \tag{14}$$

Again, the disturbance term η_t is unobserved and unknown at the present time. In case of the damage, however, the disturbance term is not member state specific, it relates to the overall deficit. Nonetheless, as stressed in section 3.1, both components of uncertainty are not expected to be independently distributed.

$$\mathbb{E}[\alpha_{n,t}(\theta_{n,t}) \cdot \gamma_t(\eta_t)] \neq 0. \tag{15}$$

Furthermore, the unexpected shocks in the damage are also assumed to leave the functions' curvature unchanged at the supranational level,

$$\frac{\partial^2}{\partial \hat{d}_{n,t} \partial \hat{d}_{m,t}} D_t(\hat{\mathbf{d}}_{\mathbf{t}}, \eta_t) \equiv \mathbb{E}\left[\frac{\partial^2}{\partial \hat{d}_{n,t} \partial \hat{d}_{m,t}} D_t(\hat{\mathbf{d}}_{\mathbf{t}}, \eta_t)\right]. \tag{16}$$

A Borrowing Constraint To directly assign a quantitative borrowing constraint to each member state, the regulatory authority solves

$$\underset{\mathbf{d_t}}{\text{Max}} \mathbb{E} \sum_{t=1}^{T} \beta^t \left[\sum_{n=1}^{N} s_{n,t}(d_{n,t}, \theta_{n,t}) - D_t(\mathbf{d_t}, \eta_t)\right]. \tag{17}$$

This optimization will result in $\hat{\mathbf{d}}_{\mathbf{t}}$, a N-vector comprising a deficit rule $\hat{d}_{n,t}$ for each region n, satisfying $\mathbb{E}\left[\frac{\partial}{\partial \hat{d}_{n,t}} s_{n,t}(\hat{d}_{n,t}, \theta_{n,t})\right] = \mathbb{E}\left[\frac{\partial}{\partial \hat{d}_{n,t}} D_t(\hat{\mathbf{d}}_{\mathbf{t}}, \eta_t)\right]$.

Ex ante (forced) commitment to such quantitative goals may, however, result in deadweight losses once the shocks are realized. After all, the ex ante do not accommodate for such uncertainty as the incorporated in the model via

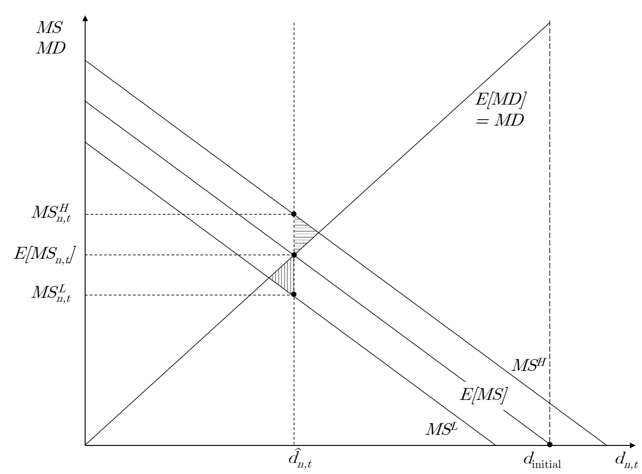

Figure 2: The Marginal Costs and Benefits of Deficit Reduction for the Overarching Regulator in case of a Borrowing Constraint

$\theta_{n,t}$. For clarification, figure 2 depicts the case for two different realizations of the marginal savings function graphically. Superscripts H and L represent the possible higher or lower realized marginal savings as a result of uncertainty. The shaded triangles represent the losses in both cases as a consequence of the realized equilibrium deviating from the optimum.

A Price Control In case of a quantity restriction, a deficit of $\hat{d}_{n,t}$ prevailed no matter what. If on the other hand, a penalty, $\tilde{p}_{n,t}$, is used as the control, achieving optimality implies fixing marginal damages such that marginal savings will not exceed this level when choosing the deficit level. The deficit in region n corresponding to such a penalty, represented by $h_{n,t}(\tilde{p}_{n,t}, \theta_{n,t})$, will be derived from the *realized* marginal savings function of reduction. This is illustrated in figure 3 for two different realizations of the marginal savings function. Superscripts H and L again represent the possible higher or lower realized marginal savings as a result of uncertainty. The actual public balance will thus be determined by stochastics as well as the penalty chosen. Therefore, an additional channel of uncertainty prevails in case of a price control.

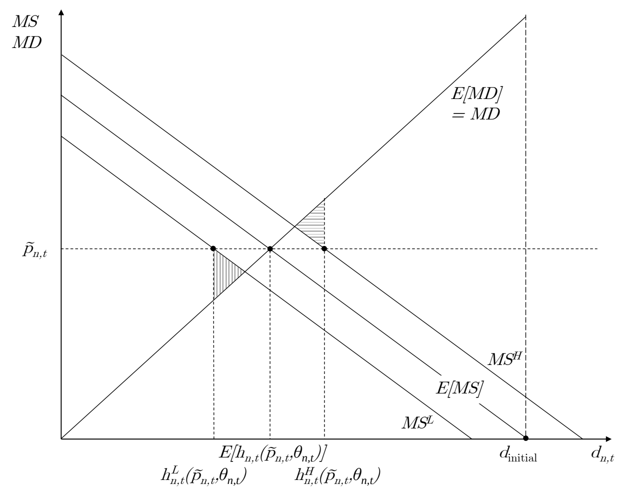

Figure 3: The Marginal Costs and Benefits of Deficit Reduction for the Overarching Regulator in case of a Price Control

More specifically, under the penalty $\tilde{p}_{n,t}$ member state n will have to adjust its path of future fiscal balances $\{d_{n,t}\}$ to the respective $h_{n,t}(\tilde{p}_{n,t}, \theta_{n,t})$, given $\tilde{p}_{n,t}$ and $\theta_{n,t}$. In particular, the penalties $\tilde{\mathbf{p}}_{\mathbf{t}} = (\tilde{p}_{1,t}, ..., \tilde{p}_{N,t})$ enforced by the regulatory authority are the result of the following optimization problem:

$$\underset{\mathbf{p}_t}{\text{Max}} \mathbb{E} \sum_{t=1}^{T} \beta^t \left[\sum_{n=1}^{N} s_{n,t}(h_{n,t}(p_{n,t}, \theta_{n,t}), \theta_{n,t}) - D_t(\mathbf{h_t}(\mathbf{p_t}, \boldsymbol{\theta_t}), \eta_t) \right], \tag{18}$$

implying

$$\mathbb{E}\left[\frac{\partial}{\partial h_{n,t}} s_{n,t}(h_{n,t}(\tilde{p}_{n,t},\theta_{n,t}),\theta_{n,t}) \cdot \frac{\partial}{\partial \tilde{p}_{n,t}} h_{n,t}(\tilde{p}_{n,t},\theta_{n,t})\right]$$
$$= \mathbb{E}\left[\frac{\partial}{\partial h_{n,t}} D_t(\mathbf{h_t}(\tilde{\mathbf{p}}_\mathbf{t},\boldsymbol{\theta_t}),\eta_t) \cdot \frac{\partial}{\partial \tilde{p}_{n,t}} h_{n,t}(\tilde{p}_{n,t},\theta_{n,t})\right] \tag{19}$$

Again, deadweight losses may result from the realized shocks due to the intervention by the federal authority, as illustrated by the shaded areas in 3. Nonetheless, the losses under both types of instrument differ for similar shocks. Hence, a comparison is fitting.

The Comparative Advantage In view of implementing fiscal discipline, policy makers should ask themselves whether, under uncertainty, a penalty is actually preferable over a quantitative borrowing constraint. Consider the case in which the regulatory authority has the choice to set a borrowing constraint ($\hat{d}_{n,t}$) according to (17) or solve for a penalty using (18). Then, the question boils down to the comparison of the loss in case of a borrowing constraint (i.e. the shaded area in figure 2) for a vector or realized shocks with that of a penalty (as illustrated in figure 3). More specifically, the comparative advantage of prices over quantities is the expected difference in gains obtained under the two modes of control and can be expressed as follows:

$$\Delta \equiv \mathbb{E}\sum_{t=1}^{T}\beta^t\Bigg[\left(\sum_{n=1}^{N} s_{n,t}(h_{n,t}(\tilde{p}_{n,t},\theta_{n,t}),\theta_{n,t}) - D_t(\mathbf{h_t}(\tilde{\mathbf{p}}_\mathbf{t},\boldsymbol{\theta_t}),\eta_t)\right)$$
$$- \left(\sum_{n=1}^{N} s_{n,t}(\hat{d}_{n,t},\theta_{n,t}) - D_t(\hat{\mathbf{d}}_\mathbf{t},\eta_t)\right)\Bigg]. \tag{20}$$

In order to select the most suitable control instrument for achieving fiscal discipline, $h_{n,t}(\tilde{p}_{n,t},\theta_{n,t})$ has to be rewritten as a function of $\hat{d}_{n,t}$. Applying the same manipulations as in the deterministic case but using the stochastic marginal cost equations from (11), one obtains

$$h_{n,t}(p_{n,t},\theta_{n,t}) \cong \hat{d}_{n,t} + \frac{p_{n,t} - \mathbb{E}\left[\frac{\partial}{\partial \hat{d}_{n,t}} s_{n,t}(\hat{d}_{n,t},\theta_{n,t})\right] - \alpha_{n,t}(\theta_{n,t})}{\frac{\partial^2}{\partial \hat{d}_{n,t}^2} s_{n,t}(\hat{d}_{n,t},\theta_{n,t})}. \tag{21}$$

Again, using the fact that in case a price control is enforced upon the member states, the realized price will equal the expected marginal savings of a deficit at $\hat{\mathbf{d}}_\mathbf{t}$, equation (21) reduces to

$$h_{n,t}(\tilde{p}_{n,t},\theta_{n,t}) \cong \hat{d}_{n,t} - \frac{\alpha_{n,t}(\theta_{n,t})}{\frac{\partial^2}{\partial \hat{d}_{n,t}^2} s_{n,t}(\hat{d}_{n,t},\theta_{n,t})}. \tag{22}$$

Nevertheless, in case of uncertainty there is no equivalence between both disciplinary controls since the second component on the right-hand side conveys the additional uncertainty characteristic of a price control in a stochastic setup.

Then, equation (22) deriving $h_{n,t}(\tilde{p}_{n,t}, \theta_{n,t})$ as a function of $\hat{d}_{n,t}$ enables the comparison of both controls. Substituting the approximated stochastic savings and damage functions, with the corresponding deficits plugged in, into (20) results in proposition 1.

Proposition 1. (Comparative Advantage) *Let $s_{n,t}(d_{n,t}, \theta_{n,t})$ be a regional stochastic savings function and let $D_t(\mathbf{d_t}, \eta_t)$ be a stochastic damage function, with $n \in \{1, ..., N\}$, $D_t''(\mathbf{d_t}, \eta_t) > 0$, $s_{n,t}''(d_{n,t}, \theta_{n,t}) < 0$, $s_{n,t}'(0, \theta_{n,t}) > D_t'(\mathbf{0}, \eta_t)$ and $D_t'(\mathbf{d_t}, \eta_t) > s_{n,t}'(d_{n,t}, \theta_t)$ for $d_{n,t}$ sufficiently large. Then, the comparative advantage of prices over quantities is determined as follows:*

$$\Delta \cong \sum_{t=1}^{T} \beta^t \left[\sum_{n=1}^{N} \frac{\sigma_{Ds,t}}{\frac{\partial^2}{\partial \hat{d}_{n,t}^2} s_{n,t}(\hat{d}_{n,t}, \theta_{n,t})} - \sum_{n=1}^{N} \frac{\sigma_{nn,t}^2}{2 \frac{\partial^2}{\partial \hat{d}_{n,t}^2} s_{n,t}(\hat{d}_{n,t}, \theta_{n,t})} \right.$$
$$\left. - \sum_{n=1}^{N} \sum_{m=1}^{N} \frac{\sigma_{nm,t} \frac{\partial^2}{\partial \hat{d}_{n,t} \partial \hat{d}_{m,t}} D_t(\hat{\mathbf{d}}_{\mathbf{t}}, \eta_t)}{2 \frac{\partial^2}{\partial \hat{d}_{n,t}^2} s_{n,t}(\hat{d}_{n,t}, \theta_{n,t}) \frac{\partial^2}{\partial \hat{d}_{m,t}^2} s_{m,t}(\hat{d}_{m,t}, \theta_{m,t})} \right], \tag{23}$$

where $\sigma_{nn,t}^2$ are the mean squared errors in the marginal savings, $\sigma_{nm,t}$ are the covariances between regional marginal savings with $m \in \{1, ..., N\}$ and $\sigma_{Ds,t}$ are the contemporaneous covariances across the regional marginal savings and the federal marginal damage.

Proof. The full derivation of (23) is reported in appendix A.3. □

Thus, introducing simultaneous uncertainty into a multitier government structure, such as federal budgetary policies, results in findings largely in line with precursory results. Lemma 1 summarizes a first important result derived from proposition 1. A graphical illustration is given by figures 4 to 7. A complete overview of the signs of the comparative advantage in the limit found are included in table 1.

Lemma 1. (Slopes) *In accordance with Weitzman's (1974) analysis without correlated uncertainty, with correlated uncertainty flatter curves for the marginal savings of a deficit and a steeper marginal damage of a deficit argue in favor of a quantitative borrowing constraint. While a flatter marginal damage curve favors a price control, policy makers turn more and more indifferent with respect to the instrument to be used the steeper the marginal savings curves are.*

Consequently, policy makers should be circumspect about the preconditions fitting a borrowing constraint. For instance, as the externalities of higher deficits grow detrimental to other regions, larger pressure is put on higher levels of government to intervene and a steeper marginal damage curve will result. Logically, rigid output controllability is highly valued in these cases. Implementing a penalty would under-represent the existing pressure for fiscal discipline. In

Table 1: Limit Signs of the Comparative Advantage of a Penalty vs. a Borrowing Constraint

	Damage	Savings Uncertainty		Damage and Savings Uncertainty					
	Uncertainty	$\sigma_{nm} \geq 0$	$\sigma_{nm} < 0$	$\sigma_{nm} \geq 0$			$\sigma_{nm} < 0$		
Case				$\sigma_{Ds} > 0$	$\sigma_{Ds} = 0$	$\sigma_{Ds} < 0$	$\sigma_{Ds} > 0$	$\sigma_{Ds} = 0$	$\sigma_{Ds} < 0$
$\lim\limits_{MD' \to 0} \Delta$	0	+	+	?	+	+	?	+	+
$\lim\limits_{MD' \to +\infty} \Delta$	0	−	−	−	−	−	−	−	−
$\lim\limits_{MS' \to 0} \Delta$	0	−	−	−	−	?	−	−	?
$\lim\limits_{MS' \to -\infty} \Delta$	0	0	0	0	0	0	0	0	0

Note: The results hold for the cases in which the inequalities hold for *all* n and m combinations, with $n \neq m$. In case there would be interregional differentiation in the variances one cannot draw unambiguous conclusions. Moreover, given its definition in equation (37) σ^2_{nn} is obviously positive.

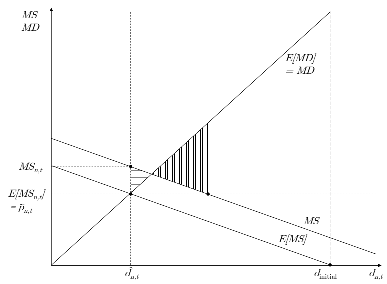

Figure 4: Deadweight Losses in case of Flat Marginal Savings

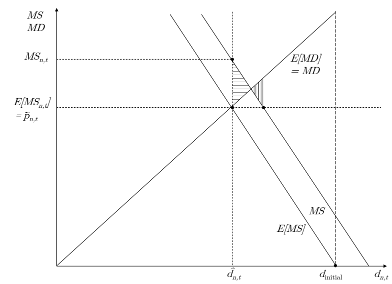

Figure 5: Deadweight Losses in case of Steep Marginal Savings

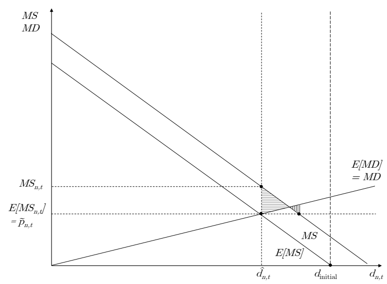

Figure 6: Deadweight Losses in case of Flat Marginal Damages

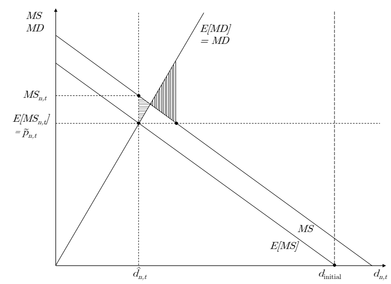

Figure 7: Deadweight Losses in case of Steep Marginal Damages

particular, the regional marginal savings of an additional unit of deficit would be put in the scale against a constant penalty, while the actual marginal damage to be taken into account is greater for higher levels of the deficit. In such cases, the slightest miscalculation or change would result in much lower or much higher than desired budget balances and would thus needlessly endanger sustainability. By contrast, with the marginal damage more constant over the deficit, i.e. policy makers are less concerned with fiscal sustainability or externalities as budget balances vary, price constraints provide an inviting option since a price instrument provides some flexibility in the amount borrowed in case actual marginal savings diverge strongly from their expectations.

If the marginal savings curves become flatter and the economy becomes more Ricardian, similar conclusions tend to hold. As regional policy makers become more and more indifferent with respect to the deficit level, Δ becomes more negative implying a comparative advantage of implementing quantitative borrowing constraints. Specifically, the remaining flexibility in regional fiscal balances in case of a penalty system might turn out in its disadvantage. After all, a comparable shock $\theta_{n,t}$ will have a much larger effect on region n's fiscal balance in case marginal savings are flat than if they were steep. The latter is undesirable as long as policy makers are strongly concerned with fiscal sustainability or externalities.

In addition to the slopes of the marginal savings and damage functions, the policy makers' choice should also take into account the savings' uncertainty. In particular, the comparative advantage depends linearly on the mean squared errors in marginal savings. Furthermore, lemma 2 is found to hold.

Lemma 2. (Regional Savings Correlation) *A positive correlation between the regional marginal savings (i.e.* $\rho_{nm,t} = \frac{\sigma_{nm,t}}{\sigma_{nn,t} \cdot \sigma_{mm,t}} > 0$*) is found to always favor a borrowing constraint as the instrument for fiscal discipline.*

Equation (24) clearly illustrates this result. Since the right hand side is strictly negative in case the correlation of regional marginal savings is positive, higher standard deviations will strengthen the case for a borrowing constraint. In case of a negative correlation ($\rho_{nm,t} < 0$), on the other hand, a price control is favored.

$$\frac{\partial \Delta}{\partial(\sigma_{nn,t} \cdot \sigma_{mm,t})} = -\frac{\rho_{nm,t} \cdot \frac{\partial^2}{\partial \hat{d}_{n,t} \partial \hat{d}_{m,t}} D_t(\mathbf{\hat{d}_t}, \eta_t)}{\frac{\partial^2}{\partial \hat{d}_{n,t}^2} s_{n,t}(\hat{d}_{n,t}, \theta_{n,t}) \frac{\partial^2}{\partial \hat{d}_{m,t}^2} s_{m,t}(\hat{d}_{m,t}, \theta_{m,t})} \tag{24}$$

Furthermore, the partial derivative of Δ with respect to the correlation of regional marginal savings is found to be unambiguously negative:

$$\frac{\partial \Delta}{\partial \rho_{nm,t}} = -\frac{\sigma_{nn,t} \cdot \sigma_{mm,t} \cdot \frac{\partial^2}{\partial \hat{d}_{n,t} \partial \hat{d}_{m,t}} D_t(\mathbf{\hat{d}_t}, \eta_t)}{\frac{\partial^2}{\partial \hat{d}_{n,t}^2} s_{n,t}(\hat{d}_{n,t}, \theta_{n,t}) \frac{\partial^2}{\partial \hat{d}_{m,t}^2} s_{m,t}(\hat{d}_{m,t}, \theta_{m,t})}. \tag{25}$$

Hence, as the shocks to the regions' marginal savings turn more symmetric, a borrowing constraint is more preferred.

As illustrated by the relation in (22), implementing a price control involves an additional channel of uncertainty. This additional channel does not only work on its own as in lemma 1, but also via its interaction with other member states' shocks. If shocks to regional marginal savings are symmetric, the overall uncertainty is more outspoken (via the second order of approximation of the federal damage function) and consequently, a price instrument is less efficient. Nonetheless, the fact that a price instrument leaves room for regional cost uncertainty to play a role turns out to be an asset in case shocks are asymmetrical and a penalty thus leaves room for regional shocks to compensate each other. Increased uncertainty in regional savings, flatter regional marginal savings curves and a steeper federal marginal damage curve, moreover, results in a greater impact of any degree of regional savings' correlations.

Damage uncertainty, in its turn, influences the outcome only via its correlation with the savings' uncertainty.[8] Therefore, consideration should also be

[8] As illustrated graphically in appendix B the deadweight losses for both policy instruments do not differ as a result of isolated shocks to marginal damages.

given to possibly correlated uncertainty of the federal marginal damage and the regional marginal savings, as it may overturn the preferred instrument of control.

Lemma 3. (Savings and Damage Correlation) *Corresponding to Stavins's (1996) setting with simultaneous uncertainty but without multiple regulated units, a positive correlation of the federal marginal damage and the regional marginal savings (i.e.* $\rho_{Ds,t} = \frac{\sigma_{Ds,t}}{\sigma_{DD,t} \cdot \sigma_{nn,t}} > 0$*) favors a quantitative borrowing constraint.*

Consider

$$\frac{\partial \Delta}{\partial(\sigma_{DD,t} \cdot \sigma_{nn,t})} = \frac{\rho_{Ds,t}}{\frac{\partial^2}{\partial \hat{d}_{n,t}^2} s_{n,t}(\hat{d}_{n,t}, \theta_{n,t})}, \tag{26}$$

where $\sigma_{DD,t}^2$ is the variance of the marginal damage, defined as:

$$\begin{aligned} \sigma_{DD,t}^2 &\equiv \mathbb{E}\left[\left(\frac{\partial}{\partial d_{n,t}} D_t(\mathbf{d_t}, \eta_t) - \mathbb{E}\left[\frac{\partial}{\partial d_{n,t}} D_t(\mathbf{d_t}, \eta_t)\right]\right)^2\right] \\ &\cong \mathbb{E}[(\gamma_t(\eta_t))^2]. \end{aligned} \tag{27}$$

When ρ_{Ds} is positive, the right-hand side of equation (26) is strictly negative. Consequently, in case of symmetric shocks, a quantity constraint becomes more attractive as the standard deviations of the regional marginal savings and the federal marginal damage grow larger. The opposite holds in case of a negative correlation (i.e. asymmetric shocks).

Additionally, as shown by equation (28), the impact of the correlation coefficient on the comparative advantage of a price control over a borrowing constraint is unambiguously negative.

$$\frac{\partial \Delta}{\partial \rho_{Ds,t}} = \frac{\sigma_{DD,t} \cdot \sigma_{nn,t}}{\frac{\partial^2}{\partial \hat{d}_{n,t}^2} s_{n,t}(\hat{d}_{n,t}, \theta_{n,t})} \tag{28}$$

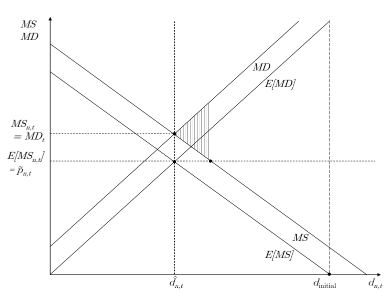

Figure 8: Deadweight Losses in case of Positively Correlated Marginal Savings and Damages

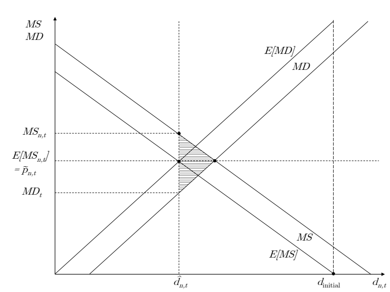

Figure 9: Deadweight Losses in case of Negatively Correlated Marginal Savings and Damages

This is also becomes clear from the graphical illustrations in figures 8 and 9. Both graphs illustrate the lemma in its most extreme form: the shocks are such that there are deadweight losses using one policy instrument, while the other is perfectly set such that losses are kept off. Increased damage and savings uncertainty as well as a flatter marginal savings curve, moreover, result in a greater impact of any degree of correlation.

Although quantitative constraints are probably the preferable instrument in the majority of cases, especially the counter-argument based on asymmetric uncertainty might be considered disturbing for present-day policy makers, as expounded in the next subsection.

3.3 Policy Implications

The framework above comprehends the case of a federal government vis-à-vis the regions. Nevertheless, given the universality of the model, it could just as well be the case for a monetary union (e.g. the EMU), in which a supranational authority oversees member countries' fiscal policies. Within a monetary union externalities are clearly no exception either. Like regional excessive deficits, spillover to other regions in a federation via the borrowing costs and the risks accompanying possible unsustainability, national deficits have recently proven to easily spillover to other union members. Moreover, at the supranational level, the trade effects of austerity via the export channel are more likely to be taken into account in the process of consolidation. Hence, supranational oversight seems worthwhile.

Within the EMU, the role of regulator is attributed to the European Commission (EC). In particular, the EC is bound to enforce the commitments made in the Stability and Growth Pact. Building on the Treaty of Maastricht, it requires member states' deficits not to exceed 3 per cent of GDP. In addition, the Pact inserted a medium term objective (MTO) for member states' budgets to be in balance or surplus in the medium term. The latter was revised in 2005 to allow countries with a debt level below 60 per cent of GDP to accrue a cyclically adjusted budget balance (CABB) of -1 per cent in the medium term.[9] More recently, the Six-Pack and the Fiscal Compact added to these quantitative requirements in light of the great recession. An increase of the MTO for a member state's structural deficit to 0.5 per cent of GDP in case the country's public debt exceeds the threshold was carried through.

3.3.1 Vertical Simultaneity Concerns

The concern with respect to the simultaneity between shocks to national marginal savings and shocks to union wide marginal damages ($\rho_{Ds,t}$) plays a key role at the supranational level. A positive correlation would imply that as a member state's marginal savings to further increase its deficit is higher than expected, the supranational regulator is confronted with a higher marginal damage of

[9] The EC however was already requiring member states to submit their CABB for evaluation from 2003 onwards.

such a deficit increase in that particular country, implying that sustainability and spillover concerns become more of an issue and a quantitative borrowing constraint would be preferable. Moreover, this concern might overwhelm the relative-slopes instrument recommendations summarized above.

Hence, as briefly mentioned in section 3.1, the term $\rho_{Ds,t}$ can be interpreted to give an indication of an uncertain factor influencing both levels of government's decisions. For instance, in case a higher deficit turns out to harm the union more than expected by endangering sustainability (for instance, by increasing interest rates more than economic growth) and the correlation is negative because member states' marginal savings are lower than expected, the comparative advantage thus favors of a price control. Similarly, a penalty-based system is preferred if the fiscal multiplier favors Keynesian deficit spending instead and both the European policy makers and member states' governments agree on this. Thus, marginal damages are lower than expected, while marginal savings are higher than expected. On the other hand, if both levels of government perceive their objective functions differently, the correlation will be positive and borrowing constraints are ceteris paribus the optimal instrument for achieving discipline.

For present-day EMU policy makers, this would mean that differing views on policy objectives for the fiscal balance among the levels of government (e.g. as a result of a national deficit bias) could rightly justify the European borrowing constraints. Otherwise, they might be backfiring in terms of economic efficiency as a penalty system would be preferred.

3.3.2 Horizontal Drivers of Inefficiency

Despite the convergence with respect to economic aspects such as trade, EMU member states have been considered to still be asymmetric in many other respects, for instance their business cycle behavior (see e.g. De Grauwe, 2012). In other words, implying diverging marginal savings of a deficit for the different member countries and making some more vulnerable to volatility. Consequently, reinforcing the case against borrowing restrictions and possibly overwhelming the above-mentioned relative-slopes and relative-shocks instrument recommendations.

As pointed out by the model, as the asymmetry between shocks to national marginal savings ($\rho_{nm,t}$) increases, the quantitative borrowing constraints enforced in the EMU are not the most efficient instruments to achieve fiscal discipline. More specifically, if shocks to budgetary policy are more asymmetric and accordingly monetary policy becomes less useful in countering the shocks in a monetary union, a borrowing constraint also leaves too little room to adjust efficiently. Namely, those countries hit the most take on too much of the burden. The latter is undesirable since it prevents an efficient form of hedging, which would not require additional government intervention.

In case of a penalty, countries have an extra degree of freedom to adjust for the asymmetric shocks, namely their fiscal balance. Thus, member states are able to adjust their budget balances according to their relative ability and willingness to bear the costs of a deficit reduction, as expressed by the realized marginal savings functions. As a result, the actual marginal savings of deficit reduction will diverge less from the marginal damage of doing so. Based on lemma 3, this is recommended if shocks are asymmetric - therefore, compensating each other - and additionally externality concerns are not decisive.

For example, take the case of two countries forming a monetary union. Suppose country A is hit by a recession, while country B's demand is blooming. To focus on the horizontal drivers of inefficiency assume there are no shifts in marginal damages. Nonetheless, under a borrowing constraint both country A and B have to adhere to the ex ante set budget balance. Given the increased marginal costs of doing so for country A and the lower marginal costs of doing so for B, the use of such an instrument is suboptimal. The respective efficiency losses are portrayed by the shaded triangles in figures 10 and 11. The social losses could be limited by using a penalty, as illustrated in figures 12 to 13. In

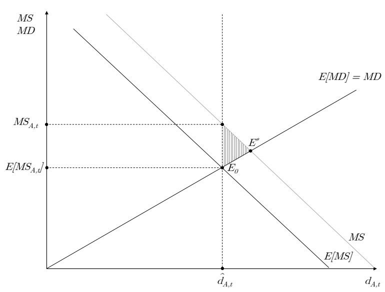

Figure 10: Country A - Deficit Rule

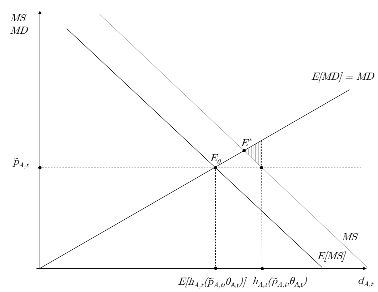

Figure 11: Country A - Penalty

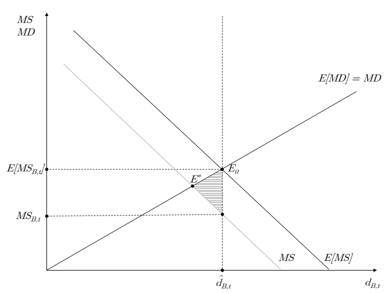

Figure 12: Country B - Deficit Rule

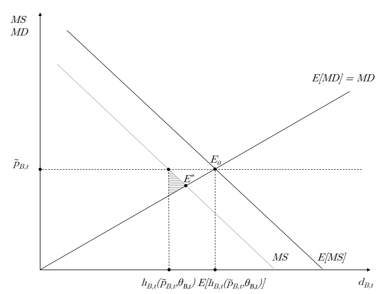

Figure 13: Country B - Penalty

that case both country A and B would be inclined to strive for fiscal discipline, yet A would choose to reduce its effort as its cuts are economically the most demanding, while B would be inclined to be more austere than under the budget constraint.[10]

[10]Note that a borrowing constraint as considered in the theoretical framework above does also not provide in an increased effort during booms. Nonetheless, this critique does not hold

The European budgetary regulation does diversify based on business cycles via explicit escape clauses to the excessive deficit procedure based on growth rates and additionally explicitly including rules based on the CABB. Thus, providing room for maneuver, albeit limited. Nevertheless, the idea that the EMU is a collection of historically, culturally and politically diverging nations only contributes to the concerns raised since other types of shocks remain.

4 Concluding Remarks

The control of budgetary aggregates is not as straightforward as it is sometimes thought to be. This paper considered two complicating considerations. Firstly, the paper accounted for the large amount of uncertainty faced by policy makers when drawing up the budgets. A problem left seemingly untouched so far. Secondly, the contradiction in preferences between the different levels of government in a multitier setup was explicitly modeled in order to account for the externalities in terms of sustainability concerns and borrowing costs currently faced by many federal states when striving for fiscal discipline and allocating austerity efforts among their member states.

Accounting for exogenous shocks to both the region-specific savings and the federation wide damages of a deficit results in three clear conclusions on the impact of uncertainty on the optimality of federal policy makers' decisions in achieving fiscal discipline. Firstly, it was found that the choice between a quantity constraint and a pecuniary penalty is determined directly by the uncertainty in the regional savings of an additional unit of deficit. Secondly, the trade off between instruments is determined only indirectly (via the correlation between savings and damage uncertainty) by the uncertainty in the federal damage of an additional unit of regional deficit, conveying possible spillovers among regions. Thirdly, a negative correlation between the stochastic components in member states' marginal savings was found to plea in favor of a penalty-based disciplinary system.

Applying the model to the supranational case furthermore pointed to two qualifications of the quantitative borrowing constraints gaining more and more ground in European fiscal policy regulation. While incorporating the standard political economy argument in favor of disciplinary action using borrowing constraints (i.e. a deficit bias) consonantly as a key parameter for optimal instrument recommendations, the model points out that the asymmetry in shocks to the costs of austerity in the different EMU member states is detrimental. The asymmetry present in current day Europe results in a comparative disadvantage of a borrowing constraint as a means of control. Certainly once the heat of a crisis wears off and sustainability concerns become subordinate. The EMU's current approach to disciplining member states is therefore highly likely to be suboptimal if kept in place in the future. An alternative penalty-based system

for the case of the EMU. It can be countered rightly by considering the Stability Programs that member states have to submit. These programs will also include required efforts once recessions blow over.

would be more efficient at hedging the EMU's characterizing uncertainty in the long run, yet not require any extra information.

In sum, policy makers either have to change strategy (i.e. instrument) in order to achieve fiscal discipline more efficiently or strive for much stronger integration to make shocks more uniform (and hence make monetary policy more powerful in countering them).[11] Alternatively, they may consider complementary hedging schemes as suggested by Drèze (2000) and stressed once more in Drèze and Durré (2013).

[11] As an alternative instrument one could possibly go even further in approximating efficiency by creating a market for tradable deficit permits as suggested by Casella (1999).

A Mathematical Appendix

A.1 Matrix Notation of the Damage Function

If the real-valued scalar function $D_t(\hat{\mathbf{d}}_\mathbf{t})$ is differentiable and continuous over the domain of the function, its gradient is

$$\nabla D_t(\hat{\mathbf{d}}_\mathbf{t}) = \left(\frac{\partial}{\partial \hat{d}_{1,t}} D_t(\hat{\mathbf{d}}_\mathbf{t}), ..., \frac{\partial}{\partial \hat{d}_{N,t}} D_t(\hat{\mathbf{d}}_\mathbf{t})\right), \tag{29}$$

where $\hat{\mathbf{d}}_\mathbf{t} = (\hat{d}_{1,t}, ..., \hat{d}_{N,t})$.

If the second-order partial derivatives of D_t all exist at the point $\hat{\mathbf{d}}_\mathbf{t}$,

$$H(D_t)_{nm}(\hat{\mathbf{d}}_\mathbf{t}) = \begin{pmatrix} \frac{\partial^2}{\partial \hat{d}_{1,t}^2} D_t(\hat{\mathbf{d}}_\mathbf{t}) & \frac{\partial^2}{\partial \hat{d}_{2,t}\partial \hat{d}_{1,t}} D_t(\hat{\mathbf{d}}_\mathbf{t}) & \frac{\partial^2}{\partial \hat{d}_{3,t}\partial \hat{d}_{1,t}} D_t(\hat{\mathbf{d}}_\mathbf{t}) & \cdots & \frac{\partial^2}{\partial \hat{d}_{N,t}\partial \hat{d}_{1,t}} D_t(\hat{\mathbf{d}}_\mathbf{t}) \\ \frac{\partial^2}{\partial \hat{d}_{1,t}\partial \hat{d}_{2,t}} D_t(\hat{\mathbf{d}}_\mathbf{t}) & \frac{\partial^2}{\partial \hat{d}_{2,t}^2} D_t(\hat{\mathbf{d}}_\mathbf{t}) & \frac{\partial^2}{\partial \hat{d}_{3,t}\partial \hat{d}_{2,t}} D_t(\hat{\mathbf{d}}_\mathbf{t}) & \cdots & \frac{\partial^2}{\partial \hat{d}_{N,t}\partial \hat{d}_{2,t}} D_t(\hat{\mathbf{d}}_\mathbf{t}) \\ \frac{\partial^2}{\partial \hat{d}_{1,t}\partial \hat{d}_{3,t}} D_t(\hat{\mathbf{d}}_\mathbf{t}) & \frac{\partial^2}{\partial \hat{d}_{2,t}\partial \hat{d}_{3,t}} D_t(\hat{\mathbf{d}}_\mathbf{t}) & \frac{\partial^2}{\partial \hat{d}_{3,t}^2} D_t(\hat{\mathbf{d}}_\mathbf{t}) & \cdots & \frac{\partial^2}{\partial \hat{d}_{N,t}\partial \hat{d}_{3,t}} D_t(\hat{\mathbf{d}}_\mathbf{t}) \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \frac{\partial^2}{\partial \hat{d}_{1,t}\partial \hat{d}_{N,t}} D_t(\hat{\mathbf{d}}_\mathbf{t}) & \frac{\partial^2}{\partial \hat{d}_{2,t}\partial \hat{d}_{N,t}} D_t(\hat{\mathbf{d}}_\mathbf{t}) & \frac{\partial^2}{\partial \hat{d}_{3,t}\partial \hat{d}_{N,t}} D_t(\hat{\mathbf{d}}_\mathbf{t}) & \cdots & \frac{\partial^2}{\partial \hat{d}_{N,t}^2} D_t(\hat{\mathbf{d}}_\mathbf{t}) \end{pmatrix} \tag{30}$$

is the Hessian of D_t at $\hat{\mathbf{d}}_\mathbf{t}$.

A.2 Derivation of the Marginal Damage Functions

Writing equation (3) in full gives

$$\begin{aligned} D_t(\mathbf{d}_\mathbf{t}) \cong{}& D_t(\hat{\mathbf{d}}_\mathbf{t}) + \begin{pmatrix} \frac{\partial}{\partial \hat{d}_{1,t}} D_t(\hat{\mathbf{d}}_\mathbf{t}) & \cdots & \frac{\partial}{\partial \hat{d}_{N,t}} D_t(\hat{\mathbf{d}}_\mathbf{t}) \end{pmatrix} \cdot \begin{pmatrix} d_{1,t} - \hat{d}_{1,t} \\ \vdots \\ d_{N,t} - \hat{d}_{N,t} \end{pmatrix} \\ &+ \frac{1}{2} \begin{pmatrix} d_{1,t} - \hat{d}_{1,t} & \cdots & d_{N,t} - \hat{d}_{N,t} \end{pmatrix} \cdot \begin{pmatrix} \frac{\partial^2}{\partial \hat{d}_{1,t}^2} D_t(\hat{\mathbf{d}}_\mathbf{t}) & \cdots & \frac{\partial^2}{\partial \hat{d}_{N,t}\partial \hat{d}_{1,t}} D_t(\hat{\mathbf{d}}_\mathbf{t}) \\ \vdots & \ddots & \vdots \\ \frac{\partial^2}{\partial \hat{d}_{1,t}\partial \hat{d}_{N,t}} D_t(\hat{\mathbf{d}}_\mathbf{t}) & \cdots & \frac{\partial^2}{\partial \hat{d}_{N,t}^2} D_t(\hat{\mathbf{d}}_\mathbf{t}) \end{pmatrix} \cdot \begin{pmatrix} d_{1,t} - \hat{d}_{1,t} \\ \vdots \\ d_{N,t} - \hat{d}_{N,t} \end{pmatrix} \\ \cong{}& D_t(\hat{\mathbf{d}}_\mathbf{t}) + \sum_{n=1}^{N} \frac{\partial}{\partial \hat{d}_{n,t}} D_t(\hat{\mathbf{d}}_\mathbf{t}) \cdot (d_{n,t} - \hat{d}_{n,t}) + \frac{1}{2} \sum_{n=1}^{N} \sum_{m=1}^{N} (d_{n,t} - \hat{d}_{n,t}) \cdot \frac{\partial^2}{\partial \hat{d}_{n,t}\partial \hat{d}_{m,t}} D_t(\hat{\mathbf{d}}_\mathbf{t}) \cdot (d_{m,t} - \hat{d}_{m,t}) \end{aligned} \tag{31}$$

Thus, given the equality of mixed partials based on Clairaut's theorem, the marginal damage function is as follows, with $i \in \{1, ..., N\} \backslash \{n\}$:

$$\frac{\partial}{\partial d_{n,t}} D_t(\mathbf{d}_\mathbf{t}) \cong \frac{\partial}{\partial \hat{d}_{n,t}} D_t(\hat{\mathbf{d}}_\mathbf{t}) + \frac{1}{2} \Bigg[2(d_{n,t} - \hat{d}_{n,t}) \frac{\partial^2}{\partial \hat{d}_{n,t}^2} D_t(\hat{\mathbf{d}}_\mathbf{t}) + \sum_{i=2}^{N} (d_{i,t} - \hat{d}_{i,t}) \cdot \frac{\partial^2}{\partial \hat{d}_{n,t}\partial \hat{d}_{i,t}} D_t(\hat{\mathbf{d}}_\mathbf{t})$$

$$+\sum_{i=2}^{N}\frac{\partial^2}{\partial\hat{d}_{i,t}\partial\hat{d}_{n,t}}D_t(\hat{\mathbf{d}}_\mathbf{t})\cdot(d_{i,t}-\hat{d}_{i,t})\Bigg]$$

$$\cong\frac{\partial}{\partial\hat{d}_{n,t}}D_t(\hat{\mathbf{d}}_\mathbf{t})+\left(\tfrac{\partial^2}{\partial\hat{d}_{1,t}\partial\hat{d}_{n,t}}D_t(\hat{\mathbf{d}}_\mathbf{t})\quad\dots\quad\tfrac{\partial^2}{\partial\hat{d}_{N,t}\partial\hat{d}_{n,t}}D_t(\hat{\mathbf{d}}_\mathbf{t})\right)\cdot\begin{pmatrix}d_{1,t}-\hat{d}_{1,t}\\ \vdots\\ d_{N,t}-\hat{d}_{N,t}\end{pmatrix}$$

$$\cong\frac{\partial}{\partial\hat{d}_{n,t}}D_t(\hat{\mathbf{d}}_\mathbf{t})+\nabla_{d_{n,t}}D_t(\hat{\mathbf{d}}_\mathbf{t})\cdot(\mathbf{d}_\mathbf{t}-\hat{\mathbf{d}}_\mathbf{t})\tag{32}$$

A.3 Proof of Proposition 1

The comparative advantage of prices over quantities is the expected difference in gains obtained under the two modes of control:

$$\Delta\equiv\mathbb{E}\sum_{t=1}^{T}\beta^t\left[\left(\sum_{n=1}^{N}s_{n,t}(h_{n,t}(\tilde{p}_{n,t},\theta_{n,t}),\theta_{n,t})-D_t(\mathbf{h}_\mathbf{t}(\tilde{\mathbf{p}}_\mathbf{t},\boldsymbol{\theta}_\mathbf{t}),\eta_t)\right)-\left(\sum_{n=1}^{N}s_{n,t}(\hat{d}_{n,t},\theta_{n,t})-D_t(\hat{\mathbf{d}}_\mathbf{t},\eta_t)\right)\right]$$

$$\begin{aligned}
&\cong\mathbb{E}\sum_{t=1}^{T}\beta^t\Bigg[\sum_{n=1}^{N}\Bigg(s_{n,t}(\hat{d}_{n,t},\theta_{n,t})-\underbrace{\frac{\partial}{\partial\hat{d}_{n,t}}s_{n,t}(\hat{d}_{n,t},\theta_{n,t})}_{=E\left[\frac{\partial}{\partial\hat{d}_{n,t}}s_{n,t}(\hat{d}_{n,t},\theta_{n,t})\right]+\alpha_{n,t}(\theta_{n,t})}\cdot\left(\frac{\alpha_{n,t}(\theta_{n,t})}{\frac{\partial^2}{\partial\hat{d}^2_{n,t}}s_{n,t}(\hat{d}_{n,t},\theta_{n,t})}\right)\\
&-\frac{1}{2}\frac{\partial^2}{\partial\hat{d}^2_{n,t}}s_{n,t}(\hat{d}_{n,t},\theta_{n,t})\cdot\left(\frac{\alpha_{n,t}(\theta_{n,t})}{\frac{\partial^2}{\partial\hat{d}^2_{n,t}}s_{n,t}(\hat{d}_{n,t},\theta_{n,t})}\right)^2\Bigg)-\sum_{n=1}^{N}s_{n,t}(\hat{d}_{n,t},\theta_{n,t})\\
&-D_t(\hat{\mathbf{d}}_\mathbf{t},\eta_t)+\sum_{n=1}^{N}\underbrace{\frac{\partial}{\partial\hat{d}_{n,t}}D_t(\hat{\mathbf{d}}_\mathbf{t},\eta_t)}_{=E\left[\frac{\partial}{\partial\hat{d}_{n,t}}D_t(\hat{\mathbf{d}}_\mathbf{t},\eta_t)\right]+\gamma_t(\eta_t)}\cdot\left(\frac{\alpha_{n,t}(\theta_{n,t})}{\frac{\partial^2}{\partial\hat{d}^2_{n,t}}s_{n,t}(\hat{d}_{n,t},\theta_{n,t})}\right)\\
&+\frac{1}{2}\sum_{n=1}^{N}\sum_{m=1}^{N}\left(\frac{\alpha_{n,t}(\theta_{n,t})}{\frac{\partial^2}{\partial\hat{d}^2_{n,t}}s_{n,t}(\hat{d}_{n,t},\theta_{n,t})}\right)\cdot\frac{\partial^2}{\partial\hat{d}_{n,t}\partial\hat{d}_{m,t}}D_t(\hat{\mathbf{d}}_t,\eta_t)\cdot\left(\frac{\alpha_{m,t}(\theta_{m,t})}{\frac{\partial^2}{\partial\hat{d}^2_{m,t}}s_{m,t}(\hat{d}_{m,t},\theta_{m,t})}\right)+D_t(\hat{\mathbf{d}}_t,\eta_t)\Bigg]
\end{aligned}$$

where all the approximated total damage and total savings cancel out. Then, under the presumptions that (a) a stochastic shock in marginal savings has no impact on the curvature of the marginal savings

$$\mathbb{E}\left[\Big(\alpha_{n,t}(\theta_{n,t})-\mathbb{E}\left[\alpha_{n,t}(\theta_{n,t})\right]\Big)\cdot\left(\frac{\partial^2}{\partial\hat{d}^2_{n,t}}s_{n,t}(\hat{d}_{n,t},\theta_{n,t})-\mathbb{E}\left[\frac{\partial^2}{\partial\hat{d}^2_{n,t}}s_{n,t}(\hat{d}_{n,t},\theta_{n,t})\right]\right)\right]=0,\tag{33}$$

(b) the covariance of shocks to marginal savings and marginal damages has no impact on the curvature of the marginal savings either and (c) there is no covariance between the curvatures of regional marginal savings

$$\mathbb{E}\Bigg[\left(\frac{\partial^2}{\partial \hat{d}_{n,t}^2} s_{n,t}(\hat{d}_{n,t},\theta_{n,t}) - \mathbb{E}\left[\frac{\partial^2}{\partial \hat{d}_{n,t}^2} s_{n,t}(\hat{d}_{n,t},\theta_{n,t})\right]\right) \cdot \left(\frac{\partial^2}{\partial \hat{d}_{m,t}^2} s_{m,t}(\hat{d}_{m,t},\theta_{m,t}) - \mathbb{E}\left[\frac{\partial^2}{\partial \hat{d}_{m,t}^2} s_{m,t}(\hat{d}_{m,t},\theta_{m,t})\right]\right)\Bigg] = 0 \tag{34}$$

working out the expectation reduces the former to:

$$\Delta \cong \sum_{t=1}^{T} \beta^t \Bigg[\sum_{n=1}^{N} \frac{\mathbb{E}\big[\gamma_t(\eta_t)\cdot\alpha_{n,t}(\theta_{n,t})\big]}{\frac{\partial^2}{\partial \hat{d}_{n,t}^2} s_{n,t}(\hat{d}_{n,t},\theta_{n,t})} - \sum_{n=1}^{N} \frac{\mathbb{E}\big[(\alpha_{n,t}(\theta_{n,t}))^2\big]}{2\frac{\partial^2}{\partial \hat{d}_{n,t}^2} s_{n,t}(\hat{d}_{n,t},\theta_{n,t})} - \sum_{n=1}^{N}\sum_{m=1}^{N} \frac{\mathbb{E}\big[\alpha_{n,t}(\theta_{n,t})\cdot\alpha_{m,t}(\theta_{m,t})\big]\cdot\frac{\partial^2}{\partial \hat{d}_{n,t}\partial \hat{d}_{m,t}} D_t(\hat{\mathbf{d}}_\mathbf{t},\eta_t)}{2\frac{\partial^2}{\partial \hat{d}_{n,t}^2} s_{n,t}(\hat{d}_{n,t},\theta_{n,t})\frac{\partial^2}{\partial \hat{d}_{m,t}^2} s_{m,t}(\hat{d}_{m,t},\theta_{m,t})}\Bigg].$$

Consequently,

$$\Delta \cong \sum_{t=1}^{T} \beta^t \Bigg[\sum_{n=1}^{N} \frac{\sigma_{Ds,t}}{\frac{\partial^2}{\partial \hat{d}_{n,t}^2} s_{n,t}(\hat{d}_{n,t},\theta_{n,t})} - \sum_{n=1}^{N} \frac{\sigma_{nn,t}^2}{2\frac{\partial^2}{\partial \hat{d}_{n,t}^2} s_{n,t}(\hat{d}_{n,t},\theta_{n,t})} - \sum_{n=1}^{N}\sum_{m=1}^{N} \frac{\sigma_{nm,t}\frac{\partial^2}{\partial \hat{d}_{n,t}\partial \hat{d}_{m,t}} D_t(\hat{\mathbf{d}}_\mathbf{t},\eta_t)}{2\frac{\partial^2}{\partial \hat{d}_{n,t}^2} s_{n,t}(\hat{d}_{n,t},\theta_{n,t})\frac{\partial^2}{\partial \hat{d}_{m,t}^2} s_{m,t}(\hat{d}_{m,t},\theta_{m,t})}\Bigg], \tag{35}$$

with the mean squared errors (i.e. the bias) in the marginal savings defined as

$$\begin{aligned}\sigma_{nn,t}^2 &\equiv \mathbb{E}\left[\left(\frac{\partial}{\partial \hat{d}_{n,t}} s_{n,t}(\hat{d}_{n,t},\theta_{n,t}) - \mathbb{E}\left[\frac{\partial}{\partial \hat{d}_{n,t}} s_{n,t}(\hat{d}_{n,t},\theta_{n,t})\right]\right)^2\right] \\ &\cong \mathbb{E}[(\alpha_{n,t}(\theta_{n,t}))^2],\end{aligned} \tag{36}$$

the covariances between regional marginal savings as

$$\begin{aligned}\sigma_{nm,t} &\equiv \mathbb{E}\Bigg[\left(\frac{\partial}{\partial \hat{d}_{n,t}} s_{n,t}(\hat{d}_{n,t},\theta_{n,t}) - \mathbb{E}\left[\frac{\partial}{\partial \hat{d}_{n,t}} s_{n,t}(\hat{d}_{n,t},\theta_{n,t})\right]\right) \\ &\quad \cdot \left(\frac{\partial}{\partial \hat{d}_{m,t}} s_{m,t}(\hat{d}_{m,t},\theta_{m,t}) - \mathbb{E}\left[\frac{\partial}{\partial \hat{d}_{m,t}} s_{m,t}(\hat{d}_{m,t},\theta_{m,t})\right]\right)\Bigg] \\ &\cong \mathbb{E}[\alpha_{n,t}(\theta_{n,t})\cdot\alpha_{m,t}(\theta_{m,t})],\end{aligned} \tag{37}$$

with $m \in \{1, ..., N\}$, and the contemporaneous covariances across the regional marginal savings and the federal marginal damage as

$$\begin{aligned}\sigma_{Ds,t} \equiv \mathbb{E}\Bigg[&\left(\frac{\partial}{\partial \hat{d}_{n,t}} D_t(\hat{\mathbf{d}}_{\mathbf{t}}, \eta_t) - \mathbb{E}\left[\frac{\partial}{\partial \hat{d}_{n,t}} D_t(\hat{\mathbf{d}}_{\mathbf{t}}, \eta_t) \right] \right) \\ &\cdot \left(\frac{\partial}{\partial \hat{d}_{n,t}} s_{n,t}(\hat{d}_{n,t}, \theta_{n,t}) - \mathbb{E}\left[\frac{\partial}{\partial \hat{d}_{n,t}} s_{n,t}(\hat{d}_{n,t}, \theta_{n,t}) \right] \right) \Bigg] \\ &\cong \mathbb{E}[\gamma_t(\eta_t) \cdot \alpha_{n,t}(\theta_{n,t})]. \end{aligned} \tag{38}$$

B Graphical Appendix

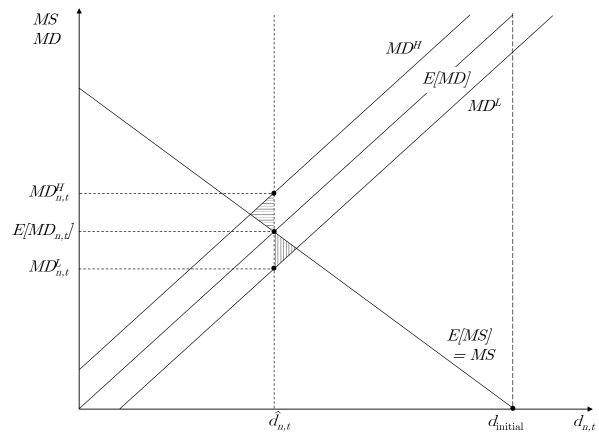

Figure 14: The Marginal Costs and Benefits of Deficit Reduction for the Overarching Regulator in case of a Benefit Shock and a Borrowing Constraint

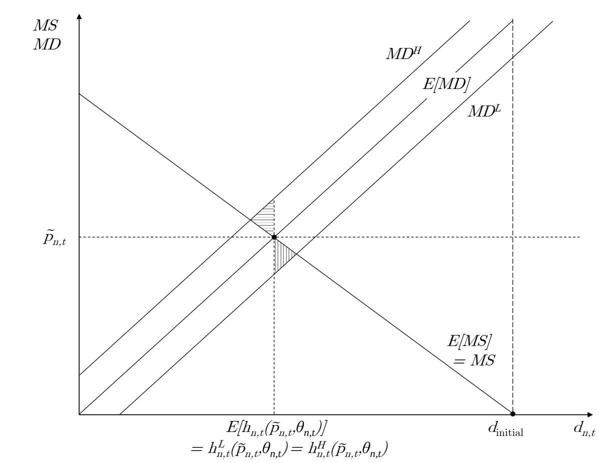

Figure 15: The Marginal Costs and Benefits of Deficit Reduction for the Overarching Regulator in case of a Benefit Shock and a Price Control

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