GOVERNMENTS' PAYMENT DISCIPLINE: THE MACROECONOMIC IMPACT OF PUBLIC PAYMENT DELAYS AND ARREARS

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This paper considers the impact of changes in the governments payment discipline on the private sector. It argues that increased delays in payments can affect private sector liquidity and profits and hence ultimately economic growth. This is then tested empirically on European Union countries using two complementary approaches. First, we use annual panel data, including a newly constructed proxy for government arrears. This approach allows us to control for more relevant variables and to capture the essence of overdue government payments, but it restricts the number of time periods and may not fully capture individual country conditions. Here we find, using panel data techniques, that payment delays and to some extent estimated arrears lead to a higher likelihood of bankruptcy, lower profits, and lower economic growth. Second, we use a Bayesian VAR approach on quarterly data for selected countries faced with significant payment delays. In this approach, we also find that the likelihood of bankruptcies rises when the government increases the average payment period.

1 Introduction

The issue of government arrears has gained prominence during the current European sovereign debt crisis. Particularly in EU/IMF programme countries – both in and outside the euro area – but also in other fiscally vulnerable economies, such as Italy and Spain, the identified amounts were considerable and measures to reduce the stock of arrears featured prominently in government strategies and as programme targets. At the same time, the European Commission took initiatives at the EU-wide level to reduce payment delays, such as the 2011 Directive on combating late payment in commercial transactions, which also covers transactions between undertakings and public authorities.[1]

Like private agents, governments have some discretion on when to pay their bills and other obligations. The outstanding payments of governments are, however, different in various respects from trade credit among private sector agents. First, within the private sector, paying a bill shifts liquidity across firms, but does not affect aggregate private sector liquidity. Second, given the size of the government, particularly in European countries, its payment policies are important to a large base of suppliers. Third, the government is at the same time a debtor and creditor, but in a very distinct way, as most of the funds owed to the government are taxes, *i.e.*, unrequited payments, whose payment terms are set by the government.

Moreover, given its size and the existing legal frameworks, the government may have an edge compared to the private sector in enforcing payments due and in collecting (versus paying) interest and fees for overdue payments. This discretion governments have in choosing when to pay

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[1] The directive, which entered into force in March 2013, imposes a maximum delay for new government payments of 30 days (60 days for a limited set of exceptions, inter alia, the health sector) and an 8 per cent surcharge for infringement.

may be foreseen already in contracts that include explicit or customary trade credit, but it can also go beyond that if governments miss due dates and fall into arrears. Payment traditions and expectations vary across countries and sectors, but as long as the situation is static the impact should be limited. If a government has a tradition of taking a long time to pay bills, then suppliers will price the cost of such credit into the goods supplied. There could still be some limited impact, though, as firms with extreme credit constraints may then not be able to do business with the government.

In times of economic crisis, however, payment delays could change in unexpected ways. Most obviously, a government facing a funding constraint could delay the payment of bills thus increasing its trade credit. Even government with full access to cheap financing could decide to delay payments, in particular if they wish to report lower public debt or deficit figures. Not paying bills typically leads to lower debt, because trade credit and even arrears are not counted under the definition of Maastricht debt according to the European accounting standards, ESA-95. Although initially proposed by Eurostat, the recent update of the public accounting standards (ESA-2010, to be enforced by the EU Member States as of September 2014) will not include the obligation to count trade credits (and arrears) under government debt. The deficit in selected years would also be reduced if measured on cash basis, but not normally if an accrual definition is used (see below for some subtleties).

Governments could also decide to accelerate payments to suppliers or previously accumulated arrears, at some stage in a crisis, in particular to support a liquidity-constrained private sector. In this spirit, the Italian government announced in April 2012 a major programme (EUR 40bn) to clear arrears over two years. This programme was extended by another government upon its investiture in March 2014, with promise for an ever larger amount (EUR 68bn). Similarly, Spain announced in May 2012 a mechanism in the form of a government guaranteed syndicated loan worth EUR 30 billion by which the central government helps regional and local governments clear their arrears.

Changes in payment lags can be expected to have implications on the macroeconomic situation through various channels.

First, corporate profits can be affected, because unexpected delays change the present discounted value of payments. If no or a low interest rate applies, this reduces suppliers profitability. Second, the size of the corporate sector can be affected if liquidity-constrained firms, in particular small and medium-sized enterprises (SMEs), go bankrupt. This will also have knock-on effects on creditors of such firms. Various second-round effects are also likely, e.g., a higher bankruptcy rate could increase the cost of capital even to firms with access to credit. Third, business investment can be affected in liquidity-constrained firms. These may not only be those directly dependent on government payments, but also their own suppliers as payment delays trickle on. Aggregate demand, and finally output and growth, could thus be negatively impacted.

The previous literature on governments' accounts payable or arrears is very limited. Diamond and Schiller (1993) provide an overview of arrears, noting how important they are in many developing countries: "in 7 out of 14 countries shown, changes in arrears were the equivalent of 10 percentage points of total recorded expenditures". They also describe the likely macroeconomic effects, but do not model or estimate them. Ramos (1998) describes how a large stock of arrears can be tackled, and recommends securitisation as an option, as it strikes a balance between addressing the needs of funding-constrained governments and creditors, and discusses the macroeconomic implications, but again without modelling or estimating them.[2] Bank of Italy

[2] The paper does present, however, a simple two-period model to illustrate the welfare gains of creditors when their arrears are recognised and securitised.

(2013) contains a short box describing an estimate of the impact of the planned initiative to clear arrears on growth. They estimate multipliers from the clearing of arrears, which are close to unity if payments are used to finance investment, 0.3 if used for firms' wage arrears and close to zero if kept for precautionary saving. Overall they estimate a positive impact on the economic growth rate of between 0.5 and 0.7 percentage points.

This paper's aim is to analyse the impact of changes in government payment delays on macroeconomic performance. To lay the foundation of this analysis, Section 2 discusses the various forms of payment delays and the extent to which they form arrears. It also describes the available data and explains the construction of our measures of arrears and delayed payments. Section 3 provides an analysis of the impact of payment delays on profits, bankruptcies and growth, using dynamic panel data techniques. Section 4 complements the previous analysis by using a Baysian VAR on quarterly data for Italy, Spain and Portugal. Section 5 brings together the findings and concludes.

2 Definitions and data availability

According to the IMF Government Finance Statistics Manual, arrears appear when "an obligatory payment is not made by its due-for-payment date". The term arrear should not be confused with general unpaid government bills or other obligations. A true arrear only occurs if a bill is not paid by the due date, whether this is based on a contractual agreement, commercial law or custom (*e.g.*, 60 days after the invoice date). A government may therefore have large amounts of unpaid bills without falling into arrears. Nevertheless an increase in unpaid bills would be indicative of potential arrears. Arrears may also occur in expenditure categories where there are no bills, such as pensions, transfers or wages. In that case, the definition is less clear, especially as the government could define the payment terms. However, a payment that occurs much later than the month to which it refers would probably be seen as an arrear.

In an accrual accounting system, such as ESA95, the timing of payments does not affect reported spending (with a few exceptions), as spending is registered at the time of good supply or service provision. If payment is not made at the same time – be it an arrear or a delay within permissible payment terms – then it shows up under the category "other accounts payable" (AF.7) in the national accounts. This category comprises any financial liability "which are created as a counterpart of a financial or a non-financial transaction in cases where there is a timing difference between this transaction and the corresponding payment. It includes trade credits and advances and any other receivables and payables. Trade credits and advances are financial assets/liabilities arising from the direct extension of credit by suppliers and buyers for goods and services transactions and advance payments for work that is in progress or to be undertaken and associated with such transactions" (see ESA95 manual).

Public accounts typically do not track true arrears, except following ad hoc audits to identify them (as sometimes required in IMF programmes). Alternative sources from international datasets do not report fiscal arrears either. For example, in the GFS, public payment arrears are a memorandum item that member countries are free to report, but rarely do. Instead, depending on the public accounting system in place, there could be data on spending commitments, payment orders and actual payments (cheque or transfer). Differences between these stages can provide indications of the development of payment lags.

First, the difference between commitments and payment orders can reflect late supply by private parties or delays by the government in issuing payment orders.

Second, the difference between payment orders and actual payments (accounts payable) is necessarily due to government procedures. An increase in this figure could, however, still take place without the government breaching due dates.

Finally, if cheques are used, there is a float as a result of uncashed cheques. This would not lead to arrears, as companies would consider a debt cleared on receipt of a cheque, unless the cheque bounces.

An unusual increase in any of these measures would indicate a potential problem, but would not be proof for the presence of arrears. Conversely, small or stable differences are not proof for the absence of arrears either, as these aggregated figures could hide individual payments with excessive delays. Moreover, if only some steps are observed, arrears can be missed. For example, if only accounts payable are known, arrears could occur because of the delayed issue of payment orders (or more generally recognition of liabilities). Finally, irregular payments, made without recording a commitment could still be potentially legally valid, but would not be known until regularised.

While it may therefore not be possible to cleanly identify arrears in a legal sense, from an economic point of view, it may be more important to identify changes in payment delays that go beyond what is expected by suppliers. Clearly accounts payable, possibly as a share of total spending would be a proxy for the average payment duration, even if an imperfect one as governments may delay or avoid recognising valid liabilities. In this paper we mainly use Eurostat's Sector Accounts data on accounts payable (ESA95 code AF.7) as a basis for further data construction. For a few countries, we also have direct estimates of arrears that allow us to make comparisons.

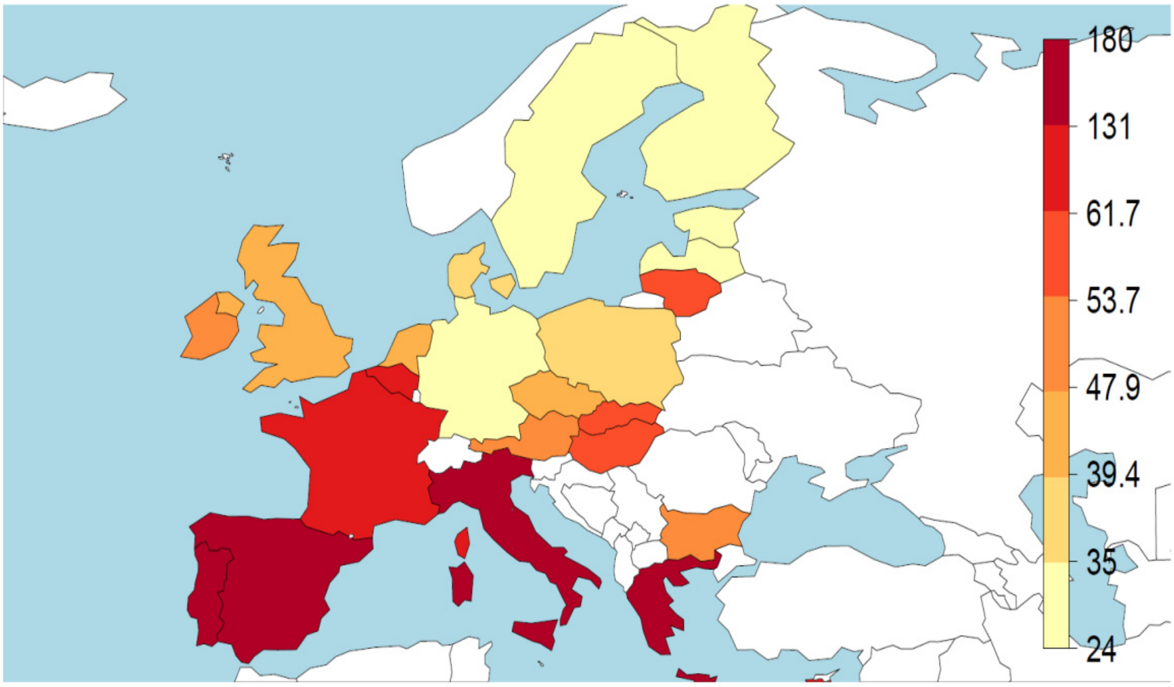
2.1 A proxy for fiscal arrears

As was mentioned, the exact amount of payments in arrears is not available from ESA95 national accounts data. Without supplementary information, it is thus very difficult to estimate the share of total accounts payable that is in arrears as opposed to the share that exists because of normal payment delays. By definition, the due-for-payment basis will show clearly the arrears arising from purchases on credit, but arrears from the failure to repay debt obligations, such as loans and securities other than shares, as scheduled will not be apparent without supplemental information. We therefore put forward a method to construct a proxy for the amount of payments in arrears based on survey data from a private credit management company (Intrum Justitia). This supplementary information on the payment duration of the public sector in several countries, provides us with a way to disentangle the share of accounts payable that are within or beyond the due-to-payment date.

To illustrate how we construct our proxy, first suppose the full information setting. In this ideal situation, we could on a given day retrieve the full payment record of the public sector (ESA 95 sector code S.13) from the national accounts. That is, on given day of a fiscal year τ and for every invoice i, we have information on (i) the amount $\$x_i$ to be paid, (ii) the contractual payment period $\bar{T}_i$and (iii) the payment duration T_i. We then say that invoice i is in arrears, if $T_i > \bar{T}_i$. For example, if the contractual period $\bar{T}_i$ is 30 days and we are 45 days from the payment date, the payment has been in arrear for 15 days. For any date τ, one could then immediately determine the amount of payments in arrears, but also construct the full duration distribution $F_T(c) = \Pr[T \leq c]$ of public payments. Hence, $1 - F_T(\bar{T})$ represents the share of payments beyond the due-to-payment date. The duration distribution of payments can therefore be used, e.g., to compare the amount of arrears.

Figure 1

Average Reported Payment Duration in 2012
(number of days)



Source: Intrum Justitia, EPI 2013.

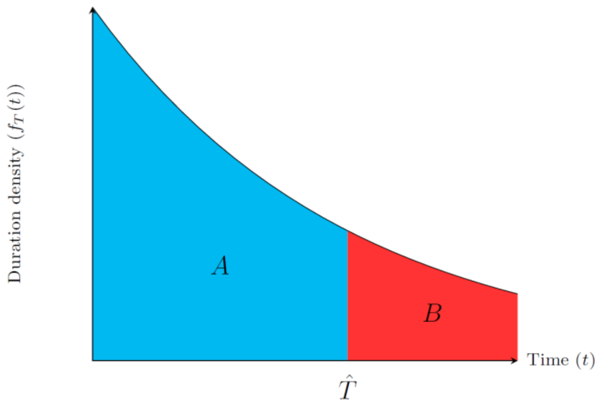
In our less ideal case, the ESA95 accounts only provide the total amount of other accounts payable (AF.7) for each country. In order to estimate the share of AF.7 that is in arrears, we first reconstruct the duration distribution of public payments. Because administrative data on the duration of public payments is not available, we use survey data on the average payment duration and the average contractual payment period of public authorities. This data is provided by the Intrum Justitia, a private credit management firm, which conducts an annual written survey among several thousand firms in 27 countries. The results from this survey are published in an annual European Payment Index (EPI) Report. Among several other payment statistics, the survey reports (i) the average annual payment duration and (ii) the average annual contractual payment period. Both numbers are further disaggregated into consumer, business-to-business and public sector debtors. We have plotted the reported data from the current EPI 2013 report in Figure 1. The map visualizes what several other studies have already documented to be a prevalent pattern in terms of payment practices in Europe (see, e.g., Ferrando and Mulier, 2013), *i.e.*, payment durations and also contractual payment periods are relatively lower in northern Europe and higher in the Mediterranean.

In order to estimate the duration distribution we assume that the duration distribution of public payments is exponential, *i.e.*, its cdf is given by:

$$F_T(t) = \begin{cases} 1 - \exp(-\lambda t) & \text{for } t \geq 0 \\ 0 & \text{for } x < 0 \end{cases},$$

Figure 2

Duration Density of Public Payments



Area A shows share of obligations within contractual payment period $\hat{T}$, area B shows share of obligations beyond the contractual period.

where $\lambda > 0$ is the parameter of the distribution and is often called *rate* or *intensity* of the distribution. The duration T decreases in λ in the sense of first order stochastic dominance, *i.e.*, higher values for T become uniformly less probable. The exponential duration is often used to model time-to-event data, such as waiting times, queuing times or the time until default in credit risk modelling. One of its key feature that motivates its use in our case is the fact that we may estimate the key parameter λ via simple methods of moments (MM). Let the reported average payment duration for country j be denoted by $\overline{T}_j$. Under weak regularity conditions, the sample average provides a consistent estimator for the mean duration of payments and hence we would estimate λ_j in the following way:

$$\mathbb{E}\left[T_j\right] = \lambda_j^{-1} \;\Rightarrow \tilde{T}_j = \hat{\lambda}^{-1} \;\Rightarrow \hat{\lambda} = \tilde{T}_j^{-1} \;. \tag{1}$$

This immediately leads to the estimated duration distribution

$$\hat{F}_T(t) = \begin{cases} 1 - \exp\left(-\hat{\lambda}t\right) & \text{for } t \geq 0 \\ 0 & \text{for } t < 0 \;, \end{cases} \;. \tag{2}$$

Hence, with information on the average payment duration, an exponential distribution of payment durations is fully identified.[3] If we do not allow for any grace period, the estimated the share of payments in arrears equals

$$\text{Other accounts payable in arrears} = AF.7\ \times (1 - \hat{F}_T(\overline{T}). \tag{3}$$

In the existing literature on the measurement of arrears, there is no general consensus which value to take for $\overline{T}$. An exact notion of payment arrears would define them to be any amounts that are past due for payment and are unpaid. Hence, any payment for which $T > \overline{T}$ would be in arrears

3 More flexible distributions that seem pertinent for our use, e.g., a Gamma distribution, feature two parameters and hence need more information than only the sample average to be identified.

under this definition. In practice, however, this strict notion of arrears is often loosened to allow for the fact that some grace period beyond the due date may be commonly granted.

In a similar vein, the IMF's Compilation Guide on Financial Soundness Indicators 2006 (see Section 4.84) defines loans to be in arrears once "(...) payments of principal and interest are past due by three months (90 days) or more (...)" and goes on to note that "The 90-day criterion is the time period that is most widely used by countries to determine whether a loan is non-performing". Since trade credit granted by the private sector to the public sector is a form of a loan, this criterion is equally applicable and provides another way to define an "acceptable grace period".

Our final estimate of the total amount of payment arrears, however, is rather sensitive to what exact value is assumed to be the "acceptable" contractual payment period. We therefore provide our estimates under all three different notions of "acceptable" below.

Under the first strict notion of arrears, we estimate for the arrears in country *j* as follows. We first use equation (2) to estimate $\hat{\lambda}$ and thus $\hat{F}_T(\cdot)$ and then evaluate one minus the estimated duration distribution at the average reported payment period $\hat{T}_j$. The final estimate for the amount of payments in arrears is then given by equation (3).

Under the second notion of arrears, we proceed very much the same way, but set $\hat{T}_j$ equal to 90 days.

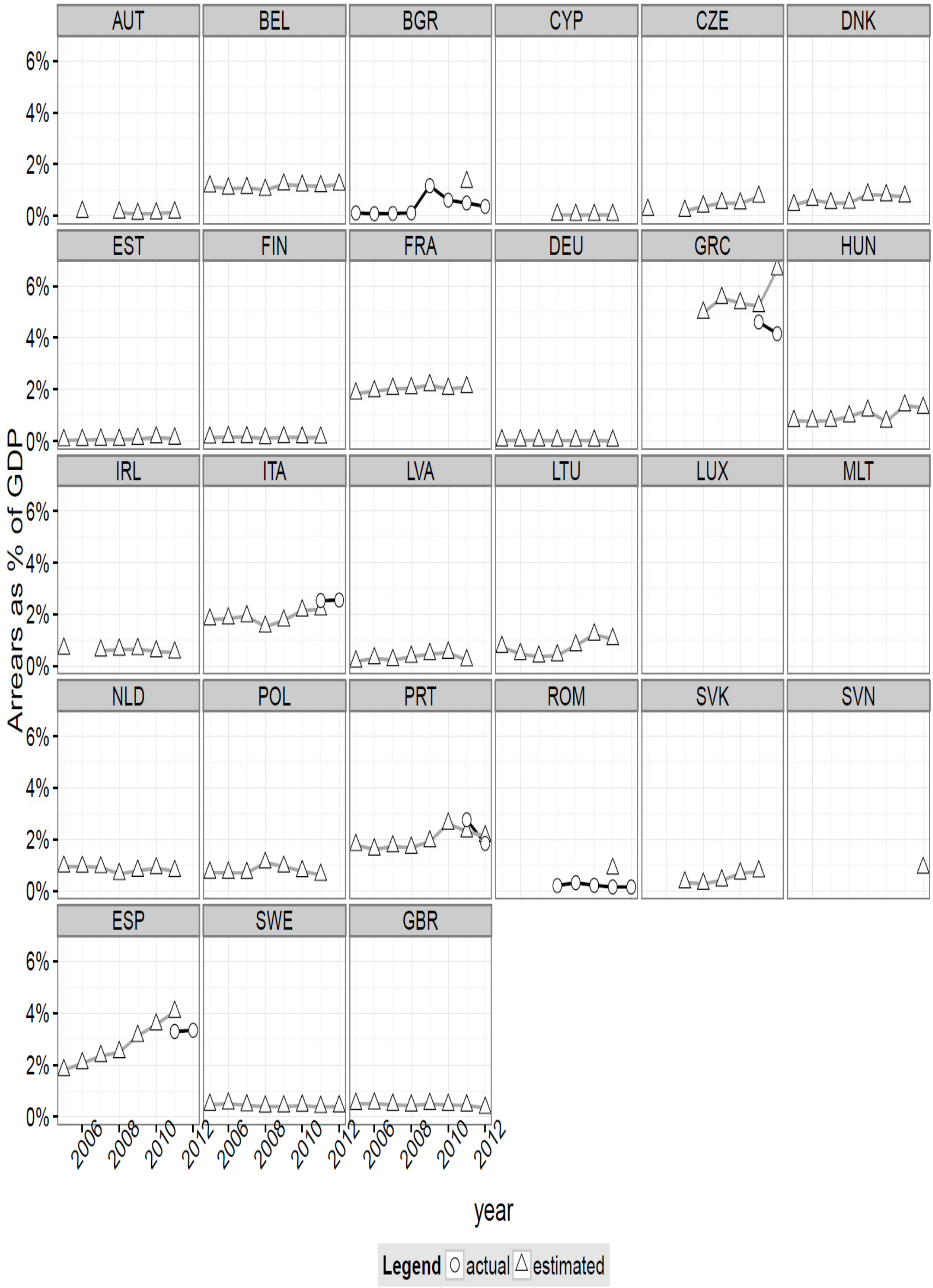
Conceptually, our third estimate for the arrears in country j is similar to the second, but allows the general government to pay after 90 days or 110 per cent of the contractual payment period. Hence, in a first step we use equation (2) to estimate $\hat{\lambda}$ and thus $\hat{F}_T(\cdot)$. In the second step, we compute $1 - \hat{F}_T(c)$ where:

$$c = \begin{cases} 90 & \text{if } \bar{T}_j \leq 90 \\ 1.1 \cdot \bar{T}_j & \text{if } \bar{T}_j > 90 \end{cases} .$$

In the final step, we take the share $1 - \hat{F}_T(c)$ from the second step and calculate the total amount of payments in arrears using equation (3). To make figures comparable, we plotted our estimates as a share of GDP in Figure 3. We also included available administrative data on actual payment arrears, e.g., when measured as part of a bailout program. There are several features worth mentioning. First, several European countries e.g. Finland, Denmark, Sweden and Bulgaria, tend to have a relatively large AF.7-to-GDP ratios. While this may be indicative of payment arrears, especially Scandinavian countries are known to roll over their debt in a timely manner and should have only very little payment in arrears – if any. Our measure incorporates this explicitly via the average payment duration in these countries. As a result, our estimates of arrears for these countries is attenuated by their high payment discipline. Second, the individual time series for the different countries show fairly little variation over time and thus appear to be very persistent. Third, the time series variation is higher for countries with relatively high Arrears-to-GDP ratios, being the highest in Greece and Spain. Fourth, in terms of matching official numbers, our estimates come surprisingly close in most cases, but may still deviate substantially in individual country-years, *e.g.*, the estimate for 2012 arrears in Greece. This deviation in some cases, however, is also very likely to stem from conflicting definitions of what is to subsumed under the term payment arrears. For example, official figures from Bulgaria do not comprise outstanding hospital bills from state-owned hospitals.

Figure 3

Actual and Estimated Payment Arrears of the Public Sector by Country



3 The aggregate effects of payment arrears – evidence from panel regressions

In a first step we estimate the macroeconomic impact of government delayed payments, arrears and total accounts payable in a panel setting, as such exploiting both the country and time variation in data. In line with the theoretical insights on the potential channels that delayed payments may have on the economy, we investigate the short-term impact on real GDP growth, on profitability as proxied by the economy-wide gross operating surplus, as well as liquidity as proxied by the probability of default (the later given by Moody's measure of distance to default, DTD).[4]

Given the large potential for endogeneity – especially reverse causation – of government delayed payments and arrears, our preferred estimator is the system GMM (Arellano-Bover) estimator for dynamic panel models. This is particularly suitable for the regressions with variables constructed based on the EPI dataset, which has a rather short time dimension (maximum T = 7, *i.e.*, the period 1995-2012) and larger cross-section dimension (the number of EU countries with sufficient observations to be kept in the regressions being 24).[5] With the GMM estimator, we also correct for the heteroskedasticity and autocorrelation that may be present in the error structure by using the consistent estimator. In general, results with other estimators, in particular fixed effects, are stronger with respect to both statistical and economic significance. Fixed-effect model results are used in particular in for regressions using accounts payable, given the longer time dimension of data (1991-2012).

3.1 Growth regressions

In this subsection, we investigate the short-term impact of government delayed payments and arrears on the real GDP growth. We begin by analysing the impact of government delayed payments, constructed as an interaction term between the variable "other accounts payable" of the general government (AF.7) as a share to GDP and the surveyed number of days public contracts are in delay, as available from EPI. We then employ our estimated measures of arrears overdue more than 90 days (as a share to GDP) and, lastly, the total accounts payable (as a share to GDP).[6] Table 3 of the Appendix shows the estimation results for various regressions starting with the simplest one in which only government delayed payments, and respectively estimated arrears, is controlled for, in addition to country and year fixed effects and two lags of the dependent variable (using only the first lagged GDP growth does not eliminate serial auto-correlation as indicated by the rejection of the AR(2) test null hypothesis). In the next columns (2) to (9), one potentially relevant variable is added at a time, as follows (by category): (i) fiscal variables: We first control for a base effect of our variable of interest by adding the government spending-to-GDP ratio (column 2) in order to capture the possibility of higher delayed payments accumulating only as a result of higher total spend ing. We then aim to capture the impact of the discretionary fiscal policy on the economy through the change of the structural primary balance ratio (column3); (ii) credit to the private sector as captured by the GDP share of loans to private entities (column 4); (iii) position in the business cycle as captured by: the output gap (column 5) and the unemployment rate (column6); (iv) basic determinants of growth in a conditional convergence model, that is labour force (population) growth rate (column 7), the saving (investment) ratio to GDP (column 8) and the

[4] The distance to default measures the number of standard deviations it takes a shock to be large enough to render a firm's asset value lower than the value of the firm's debt (see http://www.moodysanalytics.com/).

[5] The results remain robust if the difference GMM (Arellano-Bond) estimator is used instead. The same holds if the forward orthogonal transformation is used instead of differencing.

[6] Checks performed with other measures (estimated arrears overdue more than 30 or 60 days) showed less robust results.

initial level of GDP per capita (column 9). Column 10 includes all the three variables of the convergence growth model together with our variable of interest.

Overall, the results presented in Table 3 show pretty robust evidence that delayed payments have a negative impact on growth. The findings with estimated arrears (see Table 4) are more variable, and a significant result is obtained only in about half of the specifications.[7] The results with total accounts payable (not reported, but available upon request) are all insignificant, supporting the idea that large amounts that are rolled over regularly may not be a problem.

3.2 *Impact on gross operating surplus growth*

We investigate the impact of delayed payments, estimated arrears and accounts payable on the economy-wide gross operating surplus (as available from Ameco). We find a statistically significant, robust impact only in the case of delayed payments, as shown in Table 6 (the results for the other two variables of interest are presented in the Appendix).

3.3. *Impact on likelihood of bankruptcy*

As expected, government delayed payments and arrears seem to exert a stronger economic impact through indirect channels, such as the degree of liquidity constraint and likelihood of bankruptcy. We posit that such channels can be relatively well captured by the Moody's measure of a country's distance to default. In this vein, delayed payments and our measure of estimated arrears, but not the total accounts payable, are found to exert a negative effect on the distance to default (see Table 7 and 8). That is, the largest such delayed payments, the smaller the distance to default (or higher the probability of default among private companies).

4 The aggregate effect of payment arrears – evidence from Bayesian VARs

Our proxy for the payment discipline of the public sector is the AF.7-to-Expenditure ratio. Much like the debt-to-GDP ratio, the AF.7-to-Expenditure is in units of time and measures how many quarters on average the general government needs to pay its obligations, for every Euro it committed to pay. The smaller this ratio, the more efficient the general government is in a given quarter in paying its obligations. We took the ratio of AF.7 to total expenditure, instead of, e.g., the ratio to GDP, to control for the purely mechanical positive relationship between expenditure and the amount of outstanding payments. It seems natural to assume that AF.7 rises when spending increases. If the general government rolls over this additional obligations with the same efficiency, our measure of payment efficiency should not be affected. This, however, could be the case with the AF.7-to-GDP ratio. This way we also control for expenditure shocks.

The liquidity channel through which we suspect the AF.7-to-Expenditure ratio to affect the private sector is proxied by the DTD measure that was used earlier, too.

In terms of methodology, we move to a system of equations that takes each variable to be endogenous with respect to one another. This simultaneous equations framework is accommodated in a structural Bayesian VAR. Contrary to classical reduced-form VARs which identify shocks

[7] Only in regression (10), the coefficient turns insignificant, but this is in a more demanding specification with more variables and correspondingly many instruments. The very high Hansen p-value indicates possibly a problem of too many instruments having weakened the test.

using a recursive identification scheme, we wanted to allow for a less restrictive identification scheme and move towards non-recursive identification *à la* Waggoner and Zha (2003).

Bayesian VARs seem a natural alternative to the univariate framework we considered in the previous sections. First, they provide a well-established way to take into account the complex interdepencies among the variables under consideration and thus control for their mutual feedback. Second, by imposing prior restrictions on the parameters in the model we are able to address (i) the proliferation of the parameter space and (ii) the relatively small sample size, which makes it likely that an unrestricted VAR would mistake much of the sample variation to be systematic instead of unsystematic. Using prior restrictions we are able to provide conservative estimates of cross-variable effects, because we "shrink" them towards a zero prior mean (see inter alia Koop and Korobilis, 2010, for a recent account). Third, the cross-variable effects from a shock in variable j to variable i, may be easily gauged by computing the dynamic multipliers

$$\frac{\partial y_{i,t+k}}{\partial \epsilon_{j,t}} \quad , \; k = 0, \ldots \tag{4}$$

which, at the same time, control for shocks to the other variables in the system.

4.1 The data

We use a similar set of variables as in the univariate regression analysis. First, we include the standard set of macroeconomic variables, i.e. quarterly real GDP (seasonally adjusted, national currency) in log-levels, inflation as measured by the GDP deflator (2005=100), the median distance to default, the 3-month Euribor money market rate and the AF.7-to-expenditure ratio. In particular, we take the AF.7 as a ratio of total expenditure, *i.e.*, including wages and transfers.

The sample ranges are unbalanced across countries, but mostly go from 1999Q3 until 2012Q4 (see table 1). We discard countries from our analysis for which the data (i) is not available before 2002Q1, (ii) an entire series contains only missing values or (iii) one or more series contain gaps. This leaves us with 16 countries in our sample.

4.2. Non-recursive identification

In this subsection we estimate a structural VAR, *i.e.*, a model that is not generically identified using a Cholesky ordering among variables. Instead, we will follow the approach put forward by Sims (1986) and Waggoner and Zha (2003) and identify shocks directly via restrictions on the contemporaneous impact matrix. This approach is more flexible than recursive identification, because (i) it allows for non-recursive causation and (ii) restrictions can interpreted as representing behavioral equations in the sense of simultaneous equations models (SEMs). The first point plays an important role in our case, because we can implement the restriction that shocks to the AF.7-to-Expenditure ratio do not enter the equation for GDP and DTD, without having to put both to the top of the vector y_t as in a Cholesky ordering.

The key behavioral assumption in the non-recursive scheme is that shocks to the AF.7-to-expenditure ratio do *not* affect GDP and DTD contemporaneously. We base this assumption on the EPI report and the average payment duration of countries. Note that for countries where the average payment duration of one quarter (90 days), the private sector is very likely to anticipate no payment within the same quarter. *I.e.*, for any invoice dated in a given quarter, payment is expected not before the next quarter. If this holds true, then any shock to public payment durations will not affect GDP or the DTD immediately but with a lag. However, the EPI report shows that this assumption is only warranted for three countries in our sample. At the same time, the three countries – Italy, Spain and Portugal – which exhibit an average payment duration of at least 90 days are those that have been in the focus in terms of their payment discipline.[8]

To illustrate the structural BVAR model, let again $y_t \in \mathbb{R}^n$ be a n-dimensional random vector, now following the *structural* VAR model:

$$\mathbf{y}_t'\mathbf{A}_0 = \mathbf{c} + \sum_{i=1}^{p} \mathbf{y}_{t-i}'\mathbf{A}_i + \boldsymbol{\epsilon}_t' \ , \ t = 1, \ldots, T \ , \tag{5}$$

where $A_k \in \mathbb{R}^{n \times n}$ are matrices of parameters, c is an intercept and $\epsilon_t \in \mathbb{R}^n$ denotes the vector of structural shocks or disturbances in the system. We assume that ϵ_t is the standard zero-mean spherical disturbance.

Letting $x_t' = [y_t, \ldots, y_{t-p}, 1]$ and:

$$\mathbf{Y} = [\mathbf{y}_t', \ldots, \mathbf{y}_1']' \ ; \ \mathbf{X} = [\mathbf{x}_t', \ldots, \mathbf{x}_1']' \ ; \ \mathbf{E} = [\boldsymbol{\epsilon}_t', \ldots, \boldsymbol{\epsilon}_1']' \ ; \ \mathbf{F} = [\mathbf{A}_1, \ldots, \mathbf{A}_p, \mathbf{c}]'$$

we may write the whole system more compactly as:

$$\underset{T\times n}{\mathbf{Y}} \ \underset{n\times n}{\mathbf{A}_0} = \underset{T\times k}{\mathbf{X}} \ \underset{k\times n}{\mathbf{F}} + \underset{T\times n}{\mathbf{E}} \ , \tag{6}$$

where $k = np + 1$. In this form, it becomes apparent that the structural VAR may be viewed as a system of linear simultaneous equations with endogenous variables Y and exogenous (or predetermined) variables X. The system is identified imposing exclusion restrictions on the matrix A_0.

In our case, the system reads:

$$\begin{bmatrix} \text{GDP}_t \\ \pi_t \\ \text{AF.7 ratio}_t \\ \text{DTD}_t \\ i_t \end{bmatrix}' \begin{bmatrix} a_{11} & 0 & a_{31} & a_{41} & a_{51} \\ 0 & a_{22} & a_{32} & a_{42} & a_{52} \\ 0 & 0 & a_{33} & 0 & a_{53} \\ 0 & 0 & 0 & a_{44} & a_{54} \\ 0 & 0 & 0 & a_{45} & a_{55} \end{bmatrix} = \mathbf{c} + \sum_{i=1}^{p} \mathbf{y}_{t-i}'\mathbf{A}_i + \boldsymbol{\epsilon}_t' \tag{7}$$

where AF.7-ratio means the AF.7-to-Expenditure ratio. The identification assumptions we impose warrant some elaboration. The first column of A_0 represents the assumption that any contemporaneous shocks to aggregate growth are pure TFP shocks and that any feedback from the other endogenous variables affect GDP only with a lag. Hence, $\epsilon_{1,t}$ may be viewed as the TFP shock. The second column states that prices are sticky in the short run. The third columns serves to identify the shock from the AF.7-to-Expenditure ratio, in particular to set it apart from the TFP shock. It states that shocks to aggregate growth affect the average payment duration in the public sector, but not vice versa. In principle, this scheme stems from the observation that for the countries under consideration, the average payment delay is 90 days or at least very close to 90 days (see Figure 5). Thus, private suppliers are thought to anticipate this average delay and to adjust their businesses accordingly. Only once an entire quarter went past and payments still did not arrive, private suppliers realize that they had underestimated the public payment delay.

[8] For Greece the average payment duration also exceeds 90 days, but drops out according to our criteria mentioned in the section data and variable selection.

We set the following hyperparameters for the model: $\lambda_0 = 0.5, \lambda_1 = 0.1, \lambda_3 = 2$ and $\lambda_4 = 1.$[9]

Further details on the prior and the posterior simulation via Gibbs sampling can be found in Appendix C.

4.3 Empirical results

The impulse responses that derive from the structural model are depicted in Figure 6. The associated cumulative responses are given in Table 2. We restrict ourselves to report only impulse responses of interest, *i.e.*, the impulse response of the DTD, GDP and the short-term interest rate to a 10%-of-Expenditure shock. The solid black lines show the median impulse response drawn from 3,000 Monte Carlo draws from (C.9). Additionally, we have plotted two different types of error bands: the classical pointwise 68%-percentile and the joint 68 per cent error bands as proposed by Sims and Zha (1999). While the former is the more widely known measure of estimation uncertainty surrounding the impulse responses, the latter has the advantage to take into account autocorrelation in uncertainty surrounding the impulse response function.[10] The joint error bands thus depict the region around the median impulse repsonse that has a joint posterior probability of 68 per cent.[11] This illustrates that the pointwise error bands in fact depict regions that are extremely unlikely, given that there is substantial autorcorrelation in the uncertainty surrounding the impulse responses.

The model yields fairly rich dynamics in terms of the impulse responses. For the three countries under consideration, we find that private sector solvency as measured by the distance to default contracts as the average payment period of the general government increases. While for Italy, the initially negative impact gradually approaches zero and becomes insignificant after 10 or 15 quarters depending on the type of error bands, the responses in Spain and Portugal remain significantly negative in terms of the joint error bands for the whole range considered. The cumulative response of the DTD to a shock in the AF.7-to-Expenditure ratio is sizable after just 4 quarters, e.g., for Spain the annual response is such that the median distance to default is roughly 0.8 standard deviations smaller. For aggregate growth we find almost no significant impact for the three countries.

Only in Portugal the response is significantly negative, but very small in the short run. The response of the interest rates to an increase in public payment delays is ambiguous. While for example the initial response is positive in all countries, the pattern quickly reverses for Italy and Portugal and interest rates make up for the initial increase. For Italy, this renders the cumulative response even negative over the course of a year. For the other two countries, the annual response is significantly positive and economically sizeable. Even under the pointwise error bands, the response takes roughly one year to become insignificantly different from zero.

The overall results for the subset of countries in this section suggest that public payment delays affect the economy through a liquidity channel. While in aggregate terms, growth is not immediately affected (and we would arguably not expect it to do so significantly), the resilience of

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[9] We also did a prior specification search, but the marginal likelihood criterion suggested only very little shrinkage. We believe that given the small sample size, it is appropriate to be more conservative than is suggested by the prior search.

[10] The method represents the impulse response $r_{j,k}$ of variable *j* to a shock in variable *i* at horizon *k*, by means of a factor model. *I.e.*, we extract the first four principal components from the covariance matrix of sampled impulse responses and then represent the individual response $r_{j,k}$ by its median plus a term determined by the principal components, capturing the correlation with future $r_{j,k}$ s. The first four components usually explain at least 90 per cent of the variation observed in the data.

[11] Frequentist approaches to provide joint error bands build on, e.g., the Bonferroni or Tukey correction of the confidence bands (see Sims and Zha, 1999).

private sector entities – here publicly listed firms – is negatively affected. Moreover, the amount of liquidity absorbed by the central government also affects interest rates in the very short term. The three-month Euribor rate reacts with a mild increase over the first few quarters.

5 Conclusion

This paper has considered the impact of the government's payment discipline on the private sector. The overall conclusion is that government decisions on the speed of effecting payments has important repercussions for the economy. Interestingly, the crucial aspect appears to be the total amount of outstanding payments and their average delay, rather than whether or not payments are arrears in a legal or accounting sense.

Our empirical results from panel data have shown that payment delays appear to reduce profits, increase the likelihood of bankruptcies and even reduce economic growth. While the exact size of the impact is hard to estimate given variable results across specifications, results are significant in most specifications. Findings using estimated arrears are qualitatively similar, but are less often significant. This could either be interpreted as meaning that whether a payment is in arrear in a formal sense is less important than the size and average delay of payments, or it could be due to our estimation. If data on actual arrears were available, this aspect could be investigated further. Finally, on average for the European Union sample, the total amount of outstanding payments does not appear to play a role, suggesting that predictable and regularly cleared payment delays are not necessarily a problem, but rather changes in their duration.

Our results from Bayesian VARs performed on available quarterly data for Spain, Italy and Portugal, show that an increase in the average payment duration leads to (i) an increase in the likelihood of private sector defaults and (ii) in some cases a transitory increase in the short-term interest rate, *i.e.*, acts like a liquidity shock.

Based on the findings in this paper it would then appear that delaying payments to deal with a funding issue or a debt limit, is a costly way of achieving these aims. On the other hand, efforts to accelerate payments and reduce existing stocks of arrears could allow a helpful way of boosting the economy and typically would not increase deficits if all spending was properly captured when it accrued.

Figure 4

Annual AF7-to-GDP Ratio for EU-27 Countries (Croatia Excluded)

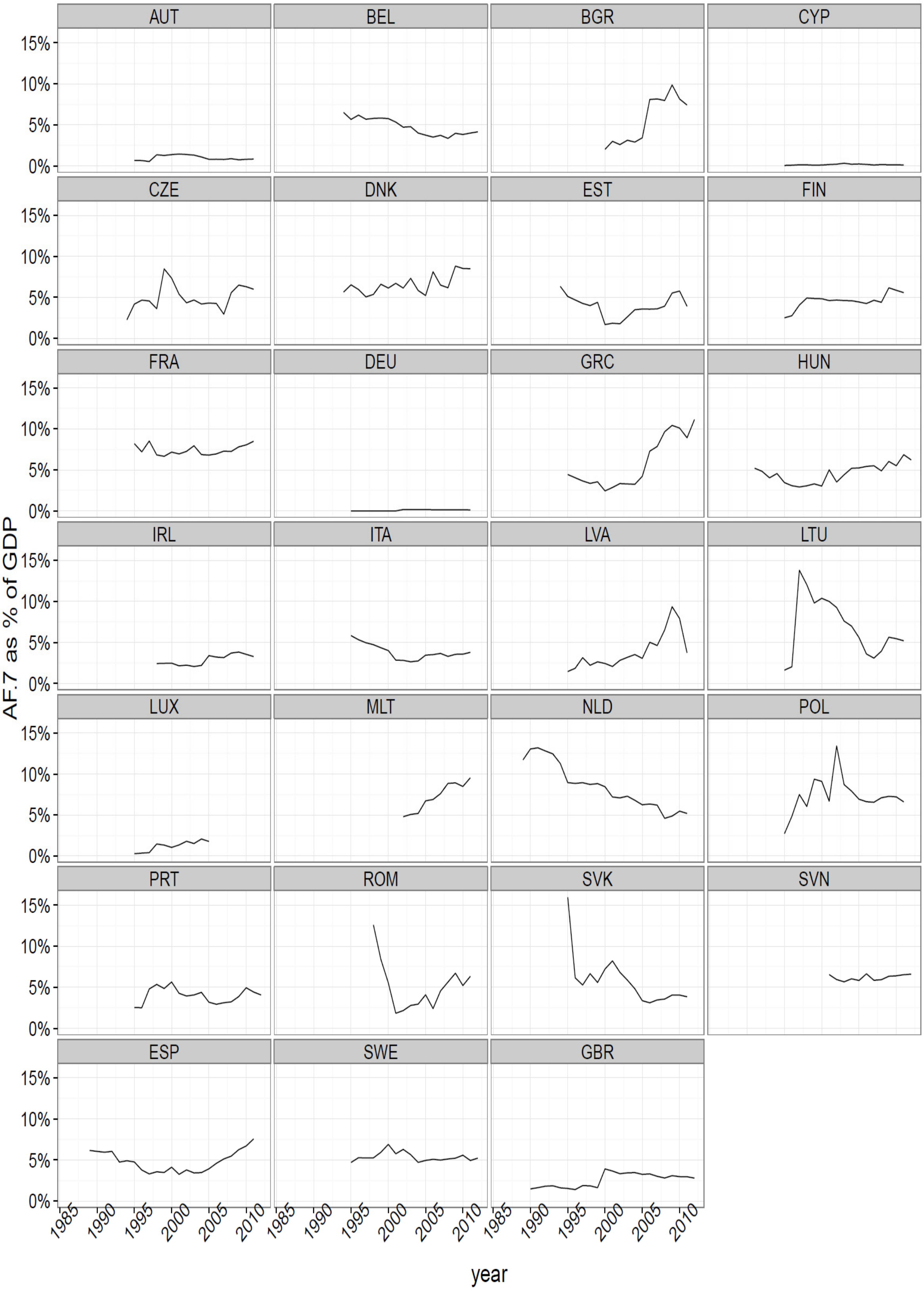
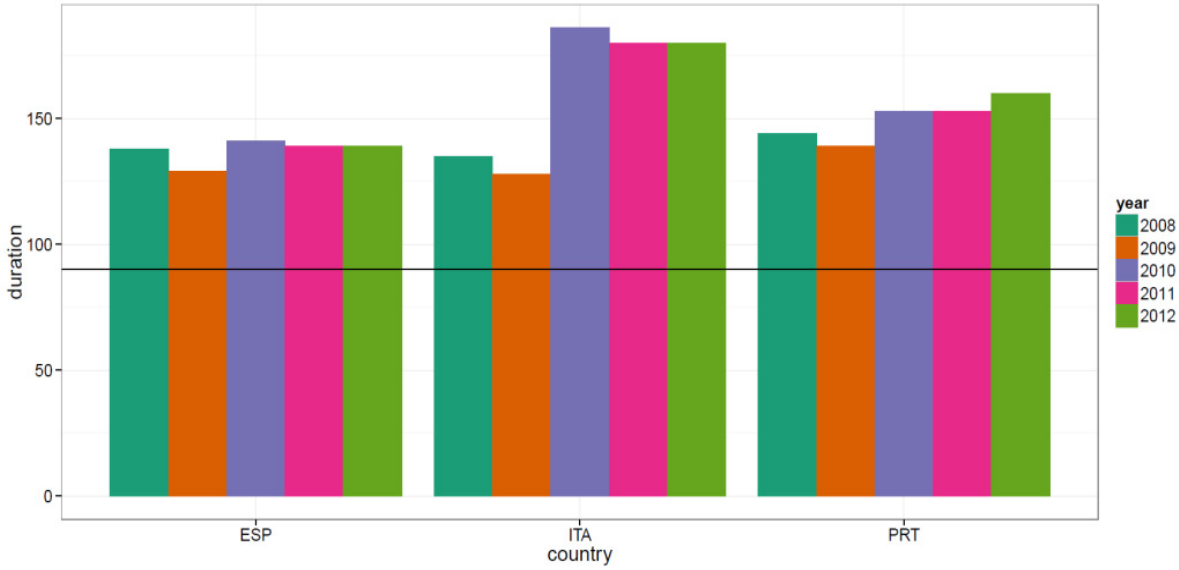


Figure 5

Average Reported Payment Duration by the Public Sector
(number of days)



Source: Intrum Justitia (EPI 2013).

Figure 6

Impulse Responses from Structural BVAR

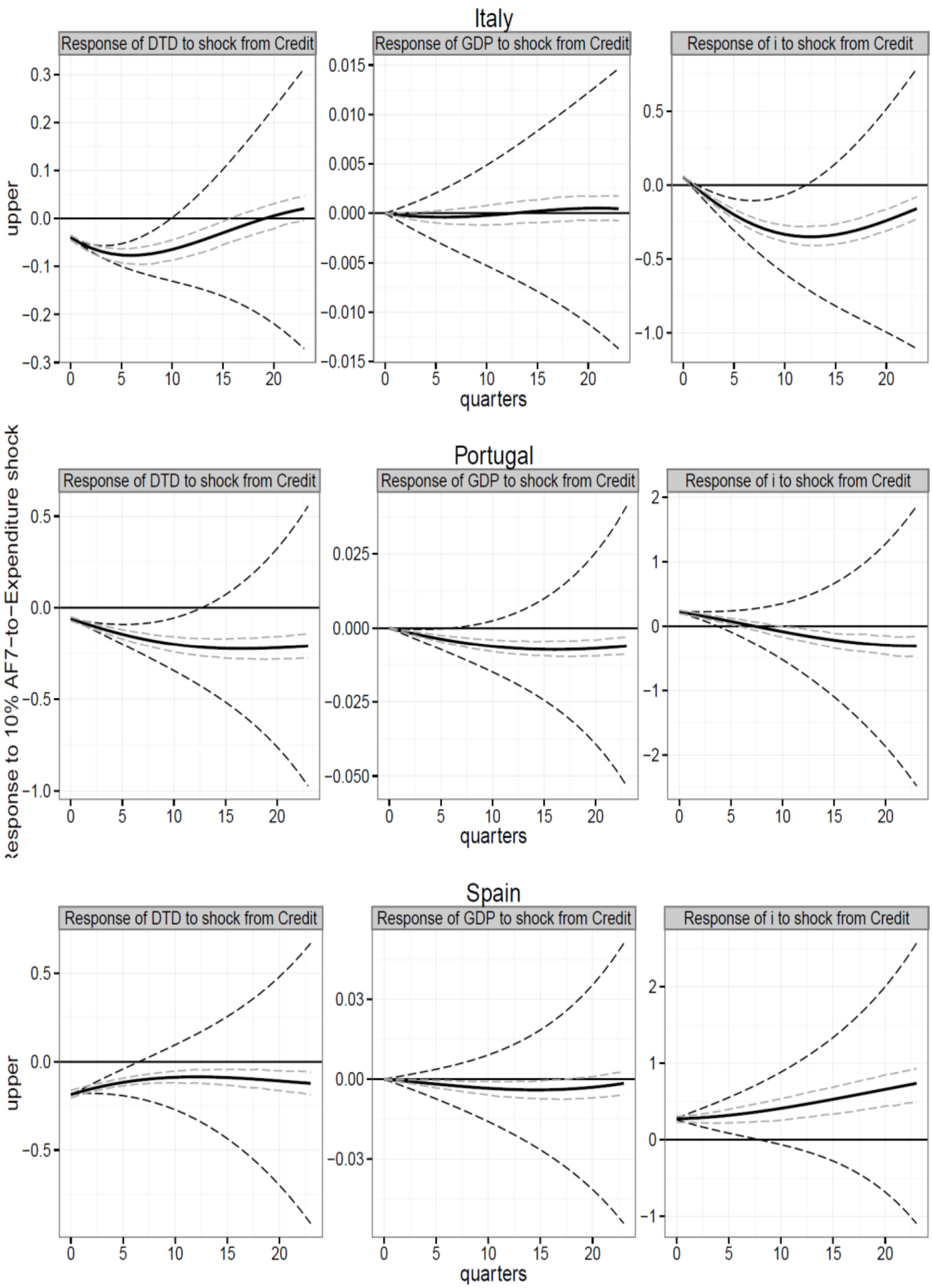


Table 1

Availability of AF.7 Quarterly Data per Country

Country	Start Date	End Date
AUT	1999Q3	2012Q4
BEL	1999Q3	2012Q4
BGR	-	-
CYP	-	-
CZE	1999Q3	2012Q4
DNK	1999Q3	2012Q4
EST	2011Q1	2012Q4
FIN	1999Q3	2012Q4
FRA	1999Q3	2012Q4
DEU	1999Q1	2012Q4
GRC	2002Q2	2012Q4
HUN	1999Q3	2012Q4
IRL	1999Q3	2012Q4
ITA	1999Q3	2012Q4
LVA	-	-
LTU	-	-
LUX	1999Q3	2012Q4
MLT	-	-
NLD	1999Q3	2012Q4
POL	1999Q3	2012Q4
PRT	1999Q3	2012Q4
ROM	2011Q2	2012Q4
SVK	2002Q3	2012Q4
SVN	2004Q2	2012Q4
ESP	1996Q3	2012Q4
SWE	1999Q3	2012Q4
GBR	1995Q2	2012Q4

Table 2

Structural Response of Variables to a 10-Percentage-point Increase in the AF.7-to-Expenditure Ratio

Country	Variable	Impulse Response – No. of Quarters Ahead				Cumulative Annual Response		
		1	2	4	8	Lower	Median	Upper
ITA	GDP	0.00	–0.00	–0.00	–0.00	–0.00	–0.00	0.00
	DTD	–0.04	–0.06	–0.07	–0.07	–0.35	–0.29	–0.23
	i	0.05	–0.06	–0.16	–0.30	–0.38	–0.28	–0.17
ESP	GDP	0.00	–0.00	–0.00	–0.00	–0.01	–0.00	–0.00
	DTD	–0.19	–0.15	–0.13	–0.10	–0.87	–0.78	–0.64
	i	0.27	0.29	0.31	0.37	1.21	1.44	1.73
PRT	GDP	0.00	–0.00	–0.00	–0.01	–0.01	–0.01	–0.01
	DTD	–0.06	–0.10	–0.13	–0.18	–0.56	–0.48	–0.40
	i	0.22	0.17	0.11	–0.02	0.64	0.82	0.96

Table 3

Estimation Results from Panel Regressions
(dependent variable: real GDP growth)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
GDP$t-1$	0.603***	0.598***	0.469***	0.586***	0.737***	0.607***	0.627***	0.599***	0.549***	0.524***
	(0.102)	*(0.105)*	*(0.0869)*	*(0.0883)*	*(0.112)*	*(0.0927)*	*(0.117)*	*(0.0938)*	*(0.101)*	*(0.121)*
GDP$t-2$	–0.351***	–0.355***	–0.365***	–0.403***	–0.161*	–0.317**	–0.332**	–0.370***	–0.406***	–0.425**
	(0.100)	*(0.0918)*	*(0.0787)*	*(0.121)*	*(0.0847)*	*(0.129)*	*(0.139)*	*(0.114)*	*(0.109)*	*(0.153)*
AF.7 × Delay	–0.00689***	–0.00687***	–0.00476**	–0.00799***	–0.00770***	–0.00766***	–0.00654***	–0.00727**	–0.00796***	–0.00467
	(0.00148)	*(0.00148)*	*(0.00180)*	*(0.00150)*	*(0.00108)*	*(0.00198)*	*(0.00191)*	*(0.00306)*	*(0.00150)*	*(0.00370)*
Expenditure ratio		–0.00484								
		(0.0656)								
Δ Primary Balance			–0.767**							
			(0.305)							
Private credit				0.00396						
				(0.0111)						
Output gap					–0.550***					
					(0.126)					
Unemployment rate						0.104				
						(0.163)				
Labor force							–0.290			0.259
							(0.498)			*(0.319)*
Savings rate								–0.0337		0.0897
								(0.0933)		*(0.0881)*
Initial real GDP									–0.269	–0.718**
									(0.478)	*(0.326)*
Constant	0.494	0.735	1.356**	0.203	–0.863	–0.530	0.454	1.247	2.445	2.832
	(0.481)	*(2.984)*	*(0.530)*	*(1.072)*	*(0.621)*	*(1.553)*	*(0.548)*	*(2.439)*	*(3.067)*	*(2.932)*
Observations	144	144	144	141	144	144	144	144	144	144
Number of countries	24	24	24	24	24	24	24	24	24	24
No. of instruments	17	22	22	22	22	22	22	22	22	32
AR(1) p	0.00358	0.00371	0.0156	0.00428	0.00536	0.00362	0.00761	0.00282	0.00286	0.00256
AR(2) p	0.237	0.288	0.401	0.315	0.290	0.205	0.398	0.270	0.455	0.598
Hansen p	0.474	0.414	0.361	0.299	0.434	0.156	0.667	0.370	0.749	0.921

Notes: Dependent variable is always annual growth rate of real GDP. All explanatory variables lagged by one year except the change in structural primary balance and the labor force growth rate. Accounts payable, spending, private credit and savings rate are in percent of GDP. All regressions include time and country fixed effects. System GMM regressions use the second to fifth lag collapsed lag as instruments. Windmeijer-corrected standard errors in parentheses below.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 4

Estimation Results from Panel Regressions

(dependent variable: real GDP growth)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
GDP$t-1$	0.618***	0.616***	0.469***	0.599***	0.759***	0.615***	0.639***	0.615***	0.555***	0.545***
	(0.105)	*(0.112)*	*(0.0907)*	*(0.0928)*	*(0.119)*	*(0.106)*	*(0.0988)*	*(0.0945)*	*(0.105)*	*(0.128)*
GDP$t-2$	–0.352***	–0.364***	–0.368***	–0.396***	–0.151*	–0.345**	–0.334**	–0.369***	–0.404***	–0.412**
	(0.105)	*(0.0973)*	*(0.0800)*	*(0.121)*	*(0.0849)*	*(0.142)*	*(0.139)*	*(0.115)*	*(0.112)*	*(0.148)*
Estimated arrears	–0.806*	–0.759	–0.676*	–1.071**	–0.982***	–0.828**	–0.790*	–0.906	–1.150***	–0.336
	(0.439)	*(0.448)*	*(0.329)*	*(0.450)*	*(0.245)*	*(0.339)*	*(0.442)*	*(0.762)*	*(0.322)*	*(0.657)*
Expenditure		0.0145								
		(0.0717)								
Δ Primary Balance			–0.777**							
			(0.284)							
Private credit				0.00295						
				(0.0113)						
Output gap					–0.568***					
					(0.127)					
Unemployment rate						0.0473				
						(0.102)				
Labor force							–0.300			0.250
							(0.441)			*(0.317)*
Savings rate								–0.0364		0.124
								(0.126)		*(0.0857)*
GDP									–0.149	–0.768**
									(0.466)	*(0.356)*
Constant	0.286	–0.421	1.382**	0.237	–1.064	–0.187	0.292	1.135	1.762	2.040
	(0.569)	*(3.205)*	*(0.562)*	*(1.091)*	*(0.654)*	*(1.066)*	*(0.546)*	*(3.288)*	*(2.914)*	*(2.761)*
Observations	144	144	144	141	144	144	144	144	144	144
Number of countries	24	24	24	24	24	24	24	24	24	24
No. of instruments	17	22	22	22	22	22	22	22	22	32
AR(1) p	0.00352	0.00354	0.0168	0.00417	0.00424	0.00370	0.00554	0.00260	0.00269	0.00242
AR(2) p	0.321	0.399	0.448	0.444	0.449	0.326	0.562	0.367	0.732	0.690
Hansen p	0.266	0.311	0.342	0.179	0.316	0.166	0.447	0.379	0.600	0.630

Notes: Dependent variable is always annual growth rate of real GDP. All explanatory variables lagged by one year except the change in structural primary balance and the labor force growth rate. Estimated arrears, spending, private credit and savings rate are in percent of GDP. All regressions include time and country fixed effects. System GMM regressions use the second to fifth lag collapsed lag as instruments. Windmeijer-corrected standard errors in parentheses below.

*** p<0.01, ** p<0.05, * p<0.1

Table 5

Estimation Results from Panel Regressions
(dependent variable: gross operating surplus)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Operating Surplus	0.260***	0.250**	0.233***	0.325***	0.233**	0.367***	0.259***	0.108	0.337***
	(0.0891)	*(0.0981)*	*(0.0819)*	*(0.101)*	*(0.0922)*	*(0.105)*	*(0.0916)*	*(0.121)*	*(0.111)*
AF.7 × Delay	–0.0130***	–0.0131**	–0.0136***	–0.0117**	–0.0198***	–0.0108**	–0.0132*	–0.00925**	–0.0114*
	(0.00455)	*(0.00468)*	*(0.00480)*	*(0.00425)*	*(0.00472)*	*(0.00475)*	*(0.00761)*	*(0.00420)*	*(0.00598)*
Expenditure ratio		0.133							0.149
		(0.298)							*(0.226)*
Private credit			–0.00697						0.00770
			(0.0155)						*(0.0149)*
Output gap				–0.702**					–0.576
				(0.282)					*(0.462)*
Unemployment rate					0.713**				
					(0.297)				
Labor force						–1.762**			–0.388
						(0.679)			*(0.906)*
Savings rate							–0.128		
							(0.303)		
GDP								0.353	
								(0.273)	
Constant	2.152	–4.022	3.101	0.351	–4.047	1.756	4.664	1.701	–7.694
	(1.258)	*(14.10)*	*(2.413)*	*(1.236)*	*(3.004)*	*(1.293)*	*(7.280)*	*(1.320)*	*(11.77)*
Observations	143	143	140	143	143	143	143	143	140
Number of countries	24	24	24	24	24	24	24	24	24
No. of instruments	17	22	22	22	22	22	22	22	37
AR(1) p	0.000839	0.00111	0.000648	0.00121	0.000965	0.00144	0.000811	0.00102	0.00153
AR(2) p	0.251	0.211	0.244	0.584	0.351	0.242	0.220	0.147	0.394
Hansen p	0.532	0.690	0.319	0.296	0.233	0.441	0.152	0.348	0.955

Notes: Dependent variable is always annual growth in gross operating surplus. All explanatory variables lagged by one year except the labor force growth rate. Accounts payable, spending, private credit and savings rate are in percent of GDP. All regressions include time and country fixed effects. System GMM regressions use the second to fifth lag collapsed lag as instruments. Windmeijer-corrected standard errors in parentheses below.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 6

Estimation Results from Panel Regressions
(dependent variable: gross operating surplus)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Operating Surplus	0.252**	0.254**	0.223**	0.325***	0.224**	0.373***	0.251**	0.110	0.362***
	(0.0903)	*(0.102)*	*(0.0866)*	*(0.103)*	*(0.0952)*	*(0.104)*	*(0.0921)*	*(0.122)*	*(0.116)*
Estimated arrears	–2.590	–2.252	–2.886	–1.225	–2.855***	–1.848	–3.027	–1.186	–1.045
	(1.587)	*(1.641)*	*(1.745)*	*(1.099)*	*(1.000)*	*(1.584)*	*(2.206)*	*(1.043)*	*(1.286)*
Expenditure ratio		0.217							0.149
		(0.337)							*(0.231)*
Private credit			0.000610						0.00559
			(0.0241)						*(0.0156)*
Output gap				–0.646**					–0.447
				(0.272)					*(0.432)*
Unemployment rate					0.635***				
					(0.212)				
Labor force						–1.901***			–0.760
						(0.663)			*(0.812)*
Savings rate							–0.334		
							(0.387)		
GDP								0.355	
								(0.287)	
Constant	3.097	–7.477	3.335	–0.0144	–3.063	2.164	10.09	1.575	–7.818
	(2.066)	*(16.01)*	*(2.875)*	*(1.547)*	*(2.354)*	*(2.126)*	*(9.747)*	*(1.617)*	*(11.99)*
Observations	143	143	140	143	143	143	143	143	140
Number of countries	24	24	24	24	24	24	24	24	24
No. of instruments	17	22	22	22	22	22	22	22	37
AR(1) p	0.00103	0.00149	0.00114	0.00135	0.00148	0.00154	0.00116	0.00101	0.00171
AR(2) p	0.273	0.213	0.271	0.615	0.394	0.262	0.205	0.158	0.381
Hansen p	0.201	0.219	0.263	0.192	0.214	0.284	0.152	0.200	0.972

Notes: Dependent variable is always annual growth in gross operating surplus. All explanatory variables lagged by one year except the labor force growth rate. Accounts payable, spending, private credit and savings rate are in percent of GDP. All regressions include time and country fixed effects. System GMM regressions use the second to fifth lag collapsed lag as instruments. Windmeijer-corrected standard errors in parantheses below.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 7

Estimation Results from Panel Regressions

(dependent variable: distance to default)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Distance to default $t-1$	0.755***		0.809***	0.880***	0.773***	0.854***	0.808***	
	(0.0935)		*(0.0948)*	*(0.0947)*	*(0.0858)*	*(0.0763)*	*(0.104)*	
AF.7 × Delay	–0.000655***	–0.00309***	–0.000578***	–0.000529***	–0.000745**	–0.000810***	–0.000735***	–0.00186*
	(0.000149)	*(0.000859)*	*(0.000192)*	*(0.000135)*	*(0.000302)*	*(0.000172)*	*(0.000246)*	*(0.00105)*
Expenditure ratio			0.0162				0.0215	0.0455**
			(0.0161)				*(0.0167)*	*(0.0222)*
Private credit				–0.000278			–8.21e–05	–0.0116*
				(0.000961)			*(0.000795)*	*(0.00606)*
Unemployment rate					0.00933		–0.00604	–0.0345
					(0.0245)		*(0.0198)*	*(0.0291)*
GDP						–0.0303*	–0.0110	–0.0412*
						(0.0162)	*(0.0147)*	*(0.0214)*
Constant	0.843***	3.063***	–0.0735	0.557**	0.725*	0.705***	–0.239	2.373*
	(0.251)	*(0.130)*	*(0.746)*	*(0.252)*	*(0.352)*	*(0.220)*	*(0.835)*	*(1.230)*
Observations	116	119	116	113	116	116	113	116
Number of countries	20		20	19	20	20	19	
No. of instruments	17	.	22	22	22	22	37	.
AR(1) p	0.0215	.	0.0155	0.0255	0.0136	0.0168	0.0169	.
AR(2) p	0.433	.	0.427	0.447	0.382	0.611	0.427	.
Hansen p	0.360	.	0.405	0.286	0.574	0.592	1.000	.

Notes: Dependent variable is always Moody's KMV Distance to Default. All explanatory variables lagged by one year except the labor force growth rate. Accounts payable, spending, private credit are in percent of GDP. All regressions include time and country fixed effects. System GMM regressions use the second to fifth lag collapsed lag as instruments. Windmeijer-corrected standard errors in parantheses below.

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 8

Estimation Results from Panel Regressions
(dependent variable: distance to default)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Distance to default $t-1$	0.767***		0.830***	0.876***	0.753***	0.877***	0.897***	
	(0.0980)		*(0.0716)*	*(0.0841)*	*(0.0777)*	*(0.0719)*	*(0.0808)*	
Estimated arrears	–0.0992***	–0.720***	–0.0642	–0.0771	–0.106**	–0.125***	–0.132***	–0.520***
	(0.0258)	*(0.135)*	*(0.0471)*	*(0.0508)*	*(0.0430)*	*(0.0308)*	*(0.0342)*	*(0.170)*
Expenditure ratio			0.0147				0.0158	0.0460**
			(0.0158)				*(0.0156)*	*(0.0217)*
Private credit				–0.000468			0.000385	–0.0116**
				(0.00138)			*(0.000723)*	*(0.00552)*
Unemployment rate					0.00603		0.00259	–0.0258
					(0.0191)		*(0.0156)*	*(0.0274)*
GDP						–0.0283*	–0.0145	–0.0278
						(0.0151)	*(0.0147)*	*(0.0222)*
Constant	0.825***	3.073***	–0.0666	0.592***	0.804**	0.664***	–0.275	2.290*
	(0.254)	*(0.133)*	*(0.774)*	*(0.203)*	*(0.313)*	*(0.218)*	*(0.808)*	*(1.192)*
Observations	116	119	116	113	116	116	113	116
Number of countries	20		20	19	20	20	19	
No. of instruments	17	.	22	22	22	22	37	.
AR(1) p	0.0215	.	0.0155	0.0255	0.0136	0.0168	0.0169	.
AR(2) p	0.433	.	0.427	0.447	0.382	0.611	0.427	.
Hansen p	0.360	.	0.405	0.286	0.574	0.592	1.000	.

Notes: Dependent variable is always Moody's KMV Distance to Default. All explanatory variables lagged by one year except the labor force growth rate. Accounts payable, spending, private credit are in percent of GDP. All regressions include time and country fixed effects. System GMM regressions use the second to fifth lag collapsed lag as instruments. Windmeijer-corrected standard errors in parantheses below.
*** p<0.01, ** p<0.05, * p<0.1

MATHEMATICAL APPENDIX

We follow Sims and Zha (1998) and Waggoner and Zha (2003) in estimating the model. Toward that end, note that the (conditional) likelihood function of the data is given as:

$$p(\mathbf{y}_1, \ldots, \mathbf{y}_T \mid \mathbf{A}) \propto |\mathbf{A}_0| \exp\left\{-\frac{1}{2}\left[\mathbf{E}'\mathbf{E}\right]\right\}$$

Conditional on $\mathbf{A}_0$ the above likelihood is quadratic in $\mathbf{F}$ and thus together with an appropriate prior $\mathbf{F} \mid \mathbf{A}_0$ is matricvariate normal. The posterior for $\mathbf{A}_0$ however turns out to be non-standard and requires further processing. The exclusion restrictions we impose on each of the columns of $\mathbf{A}_0$, may be represented by the restriction matrices Q_i of rank q_i:

$$\mathbf{Q}_i \mathbf{a}_i = \mathbf{0} \ . \tag{8}$$

Elements of $\mathbf{F}$ may be restricted in a similar way via a matrix $\mathbf{R}_i$ that has rank r_i. As has been demonstrated by Waggoner and Zha (2003), $\mathbf{a}_i$ anf $\mathbf{f}_i$ will satisfy the above restrictions, if there exists a $n \times q_i$ matrix $\mathbf{U}_i$ and $n \times r_i$ matrix $\mathbf{V}_i$, such that:

$$\mathbf{a}_i = \mathbf{U}_i \mathbf{b}_i \tag{9}$$

$$\mathbf{f}_i = \mathbf{V}_i \mathbf{g}_i \ . \tag{10}$$

The matrix $\mathbf{U}_i$ may be found via a singular value decomposition, that takes $\mathbf{U}_i$ to be the matrix of right-singular vectors that lie in the Null space of diag($\mathbf{a}_i$). The set of parameters given by $\mathbf{b}_i$ and denotes $\mathbf{g}_i$ is the set of parameters that is free to estimate.

Our prior on ($\mathbf{a}_i$, $\mathbf{f}_i$) is of the form:

$$p(\mathbf{A}_0) p(\mathbf{F} \mid \mathbf{A}_0) \ . \tag{11}$$

where:

$$\mathbf{a}_i \sim N(\mathbf{0}, \underline{\mathbf{S}}_i) \ ; \ \underline{\mathbf{S}}_i = \mathrm{diag}\left(\frac{\lambda_0^2}{\sigma_i^2}\right) \ , \tag{12}$$

$$\mathbf{f}_i \mid \mathbf{a}_i \sim N(\underline{\mathbf{P}}_i \mathbf{a}_i, \underline{\mathbf{H}}_i) \ ; \ \underline{\mathbf{P}}_i = \left[\mathbf{I}_n, \mathbf{0}_{n(p-1)+1\times n}\right] \ ; \ \underline{\mathbf{H}}_i = \begin{bmatrix} \left(\frac{\lambda_0 \lambda_1}{l^{\lambda_3} \sigma_i}\right)^2 \mathbf{I}_k & \mathbf{0}_{k-1} \\ \mathbf{0}_{1\times k-1} & \lambda_0^2 \lambda_4^2 \end{bmatrix} \tag{13}$$

This prior on ($\mathbf{a}_i$, $\mathbf{f}_i$) is then mapped to a prior on ($\mathbf{b}_i$, $\mathbf{g}_i$) (we refer the reader to Waggoner and Zha, 2003 for any details):

$$\mathbf{b}_i \sim N(\mathbf{0}, \tilde{\mathbf{S}}_i) \ ; \ \tilde{\mathbf{S}}_i = (\mathbf{U}_i' \underline{\mathbf{S}}_i \mathbf{U}_i)^{-1} \tag{14}$$

$$\mathbf{g}_i \mid \mathbf{b}_i \sim N(\tilde{\mathbf{P}}_i \mathbf{b}_i, \tilde{\mathbf{H}}_i) \ ; \ \tilde{\mathbf{P}}_i = \underline{\mathbf{P}}_i \mathbf{U}_i \ ; \ \tilde{\mathbf{H}}_i = \underline{\mathbf{H}}_i \ . \tag{15}$$

Combining this prior with the likelihood, the posterior is found to be:

$$p(\mathbf{b}_i, \mathbf{g}_i \mid \mathbf{Y}) = p(\mathbf{b}_1, \ldots, \mathbf{b}_n \mid \mathbf{Y}) \prod_{i=1}^{n} p(\mathbf{g}_i \mid \mathbf{b}_i, \mathbf{Y}) \tag{16}$$

where:

$$p(\mathbf{g}_i \mid \mathbf{b}_i, \mathbf{Y}) = N(\overline{\mathbf{P}}_i\mathbf{b}_i, \overline{\mathbf{H}}_i) \; ; \; \overline{\mathbf{P}}_i = \mathbf{H}_i \left(\mathbf{V}_i'\mathbf{X}'\mathbf{Y}\mathbf{U}_i + \tilde{\mathbf{H}}_i^{-1}\tilde{\mathbf{P}}_i\right) \tag{17}$$

$$\overline{\mathbf{H}}_i = \left(\mathbf{V}_i'\mathbf{X}'\mathbf{X}\mathbf{V}_i + \tilde{\mathbf{H}}_i^{-1}\right)^{-1} \tag{18}$$

and:

$$p(\mathbf{b}_1, \ldots, \mathbf{b}_n \mid \mathbf{Y}) = |[\mathbf{U}_1\mathbf{b}_1, \ldots, \mathbf{U}_n\mathbf{b}_n]|' \exp\left\{-\frac{T}{2}\sum_{i=1}^{n}\mathbf{b}_i'\mathbf{S}_i\mathbf{b}_i\right\} \tag{19}$$

with:

$$\mathbf{S}_i = \left(\frac{1}{T}\left[\mathbf{U}_i'\mathbf{Y}'\mathbf{Y}\mathbf{U}_i + \tilde{\mathbf{S}}_i + \tilde{\mathbf{P}}_i'\tilde{\mathbf{H}}_i^{-1}\tilde{\mathbf{P}}_i - \mathbf{P}_i'\mathbf{H}_i^{-1}\mathbf{P}_i\right]\right)^{-1} . \tag{20}$$

In order to estimate the model, we use the Waggoner-Zha Gibbs sampler, because there is no straightforward way to sample from equation (16). Especially the fact that $\mathbf{b}_i$ appears in the determinant of equation (19) makes the posterior of $\mathbf{b}_i$ non-normal. Waggoner and Zha (2003) show that, alternatively, one may sample from:

$$p(\boldsymbol{\beta}_1, \ldots, \boldsymbol{\beta}_{q_i} \mid \mathbf{b}_{-i}, \mathbf{Y}) \propto |\boldsymbol{\beta}_1|' \exp\left\{-\frac{T}{2}\sum_{i=1}^{q_i}\boldsymbol{\beta}_i^2\right\} \tag{21}$$

where:

$$\mathbf{b}_i = \mathbf{T}_i \sum_{i=1}^{q_i} \boldsymbol{\beta}_i \mathbf{w}_i \tag{22}$$

denotes the set of $\mathbf{b}_j$ such that $j \neq i$,

$$\mathbf{T}_i\mathbf{T}_i' = \mathbf{S}_i \tag{23}$$

and $w_1, \ldots, w_{q_i}$ form an orthogonal basis of $\mathbb{R}^{q_i}$.[12]

Thus, we use orthogonalization approach of Waggoner and Zha (2003) to devise the following Gibbs sampler:

1. Choose a starting value $\mathbf{A}_0^{(0)}$ satisfying equation (8).[13]
2. Draw $\mathbf{A}_0^{(s)}$ conditional on $(\mathbf{F}^{(s-1)}, \mathbf{Y})$: for $i = 1, \ldots, n$ draw $\beta_1, \ldots, \beta_{q_i}$ from equation (21) conditional on $\mathrm{b}_1^{(s)}, \ldots, \mathrm{b}_{i-1,}^{(s)} \mathrm{b}_{i+1,}^{(s-1)}, \mathrm{b}_{n,}^{(s)}$, and let $\mathrm{b}_i^{(s)}$ be defined by equation (22) and take $\mathbf{a}_i = \mathbf{U}\ \mathbf{b}_i^{(s)}$.
3. Draw $\mathbf{F}^{(s)}$ conditional on $(\mathbf{A}_0^{(s)}, \mathbf{Y})$ from equation (17).

[12] E.g., use the Gram-Schmidt method to find them.

[13] We take the posterior mode of the marginal posterior of $\mathbf{A}_0$ which we find by numerical maximization (Nelder-Mead then BFGS).

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