

Winter, Christoph; Kraus, Beatrice

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## Do Tax Changes Affect Credit Markets and Financial Frictions? Evidence from Credit Spreads

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# Do Tax Changes Affect Credit Markets and Financial Frictions?

## Evidence from Credit Spreads\*

Beatrice Kraus<sup>†</sup> and Christoph Winter<sup>‡</sup>

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### Abstract

In this paper, we empirically document a link between tax changes and financial market conditions. Using the Romer and Romer (2010) narrative record of exogenous federal tax liability changes for the US, we show that an increase in taxes leads to higher risk premia for corporate bonds issued by financial and non-financial firms. Consistent with recent theories of intermediary asset pricing, we demonstrate that risk premia are driven by intermediaries' balance sheet conditions, which – according to our results – are, in turn, affected by tax changes. Two tax acts are particularly relevant for the transmission of taxes to financial market conditions, namely the Tax Reform Act of 1986 and the Jobs and Growth Tax Relief Reconciliation Act of 2003. Interestingly, none of these two tax acts specifically targeted the financial sector. Therefore, an important implication of our results is that any tax change can potentially spill over to financial market conditions, with the associated consequences for real economic activity.

*Keywords:* tax changes; credit spreads; financial frictions; financial intermediaries

*JEL classification:* E44; E62; G20

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<sup>†</sup>Swiss National Bank, Bundesplatz 1, CH-3003 Bern. E-Mail: [beatrice.kraus@snb.ch](mailto:beatrice.kraus@snb.ch)

<sup>‡</sup>Department of Economics, University of Zurich, Schönberggasse 1, CH-8001 Zürich. E-Mail: [christoph.winter@econ.uzh.ch](mailto:christoph.winter@econ.uzh.ch)

# 1 Introduction

In this paper, we document a novel channel through which tax changes affect economic activity, namely financial frictions. Using VARs, we show that exogenous tax changes have a sizable impact on corporate bond spreads. We identify exogenous tax changes in the US for the post-World War II period using the narrative account by Romer and Romer (2010). In order to avoid anticipation effects, we focus on unanticipated tax changes, in the spirit of Mertens and Ravn (2012). Using our measure of exogenous, unanticipated tax liability changes, we find that an increase in tax liabilities/GDP by one percentage point raises corporate bond spreads by between one and two percentage points.

Research regarding the economic effects of tax changes has focused on real economy activity, see e.g. Blanchard and Perotti (2002), Romer and Romer (2010), Mertens and Ravn (2011, 2012, 2013), and the recent survey by Ramey (2016). We know from this strand of literature that increasing tax liabilities has large contractionary effects on real economic activity, in particular on GDP and investment. Since corporate bond spreads are negatively correlated with real economic activity (see e.g. Gilchrist and Zakrajšek 2012), the response of corporate bond spreads to an increase in tax liability changes could simply be the by-product of the adverse impact of taxes on the general economic environment.<sup>1</sup>

To address this concern, we use the excess bond premia of financial and non-financial corporate firms, as constructed by Gilchrist and Zakrajsek (2011, 2012). Gilchrist and Zakrajsek (2011, 2012) decompose the spread between the yields of corporate bonds and Treasuries of the same maturity and payment structure into two components: one that captures the countercyclical movements in expected default rates and another component measuring the procyclical variation between the expected default risk and the credit spread. This latter component is what Gilchrist and Zakrajsek (2011, 2012) call the excess bond premium. By construction, the excess bond premium measures the willingness of the market to accept default risk of corporate firms, i.e. the effective risk aversion. Put differently, excess bond premia are “[...] interpretable as a pure measure of the spread between yields on private versus public debt that is due to financial market frictions” (Gertler and Karadi 2015, p. 60).

Our findings regarding the rise in risk aversion following a tax increase have important implications for our understanding of the transmission of tax changes to real economic activity. As noted by Mertens and Ravn (2011) and Kraus and Winter (2015), the sizable empirical effects of taxes on certain variables, in particular on durable purchases and investment, are difficult to reconcile with standard macroeconomic models of tax transmission. Our results suggest that this is because standard models do not account for financial frictions. In models with financial frictions, such as Bernanke and Gertler (1995), Kiyotaki and Moore (1997), Bernanke, Gertler, and Gilchrist (1999), Gertler and Kiyotaki (2010), and Hall (2011), tighter frictions adversely affect credit supply, with substantial consequences for aggregate economic activity. Therefore, to the extent that these theories imply that financial frictions tighten after a tax increase, they can potentially account for the sizable tax multipliers observed in the data.<sup>2</sup>

As a second contribution, we do not only document that tax changes possibly affect financial frictions, but also analyze why this is the case. In a first step, we distinguish between corporate and personal

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<sup>1</sup>As Philippon (2009) makes clear, even in the absence of financial frictions, corporate bond spreads react to changes in expected default risk.

<sup>2</sup>In our companion paper (Kraus and Winter 2015), we discuss to what extent standard models of financial frictions are consistent with a positive comovement between taxes and financial frictions.

income tax adjustments using information from Mertens and Ravn (2013). We find that corporate bond spreads respond to both types of tax changes. This finding rules out that credit spreads only respond to tax changes because firms alter their mix of equity and debt financing in order to avoid higher corporate income taxes. We can also rule out that our results are driven by the financial crisis, since the last exogenous unanticipated tax change that we use in our analysis is the Jobs and Growth Tax Relief Reconciliation Act (JGTRRA) of 2003. Moreover, because we only analyze federal tax acts, which affect interest payments on both corporate and government bonds alike, they should, *ceteris paribus*, leave corporate bond spreads unchanged.<sup>3</sup>

In a next step, in order to understand the link between taxes and financial frictions, we focus on the determinants of excess bond premia. Recent empirical and theoretical evidence suggests that financial intermediaries are central for understanding the behavior of corporate bond spreads (see e.g. Collin-Dufresne, Goldstein, and Martin 2001). In particular, the risk appetite of financial intermediaries appears to be driven by their balance sheet conditions (see e.g. the theoretical models by He and Krishnamurthy 2013 and Brunnermeier and Sannikov 2014, or Adrian, Moench, and Shin 2010, Adrian and Shin 2010a, and Adrian, Colla, and Shin 2012, who provide empirical evidence on the link between risk premia and intermediaries' balance sheet conditions).<sup>4</sup>

Based on this evidence, we test to what extent tax changes also affect intermediaries' balance sheet conditions. We do this with the help of the 'dummy variable approach' by Ramey and Shapiro (1998) and Burnside, Eichenbaum, and Fisher (2004), which allows us to disentangle the overall effect of taxes into the contribution of specific tax acts. Using this method, we can analyze *whether* financial intermediaries' balance sheet conditions respond to the same tax acts as excess bond premia. Moreover, with the help of detailed information about each tax act, we can also determine *why* financial intermediaries' balance sheet conditions (and therefore excess bond premia) react after a specific tax act.

We find that intermediaries' balance sheet conditions and excess bond premia simultaneously respond to two tax acts, namely to the Tax Reform Act (TRA) of 1986 and to the 2003 JGTRRA. It is important to stress that none of these two tax events were directly targeted at the financial sector.<sup>5</sup> The 1986 TRA affects intermediaries' balance sheet conditions because it leads to an increase in the fraction of non-performing loans. We relate this increase to the adverse effects of the 1986 TRA on capital-intensive industries such as mining (see Cutler 1988).

On the other hand, the 2003 JGTRRA has a major impact on personal income taxes, in particular on the taxation of dividends and capital gains. In line with a large literature that finds that changes in dividend/capital gain taxes have an impact on stock prices (see Sialm 2009), we document that the 2003 JGTRRA has a significant effect on equity valuations.<sup>6</sup> Corporate equity is the second largest asset in balance sheets of the financial industry. We therefore conclude that the 2003 JGTRRA affects intermediaries' balance sheet conditions via changes in stock prices. Interestingly, we find that the

<sup>3</sup>This would be different if we considered *state*-level tax changes, since in the US, interest payment on government bonds are not subject to state-level taxation.

<sup>4</sup>Brunnermeier, Eisenbach, and Sannikov (2012) survey the theoretical literature.

<sup>5</sup>The 1986 TRA changed the deductibility of loan loss provisions from banks' income statements, as described by Kuprianov (1997). We will argue that this not the reason why the 1986 TRA affects financial intermediaries' balance sheet conditions. Gambacorta et al. (2016) present evidence on the impact of tax changes on the liability structure of banks.

<sup>6</sup>See also Auerbach and Hassett (2005, 2006) for related evidence.

overall impact of personal income tax changes on equity valuations, the intermediaries' return on assets, and excess bond premia is entirely driven by the 2003 JGTRRA.

In conclusion, our results suggest that the rise in excess bond premia after an increase in tax liabilities is due to strains in the financial sector, which might have general implications for the supply of credit, both through the corporate bond market and through the banking sector in general.

Our paper therefore contributes to the growing literature that documents possible linkages between fiscal policy and financial market conditions, see e.g. Fernández-Villaverde (2010), Carrillo and Poilly (2013), Melina and Villa (2014), Canzoneri et al. (2015), Ji and Qian (2015), and Röhrs and Winter (2015). Most of these papers focus on government spending multipliers (see Carrillo and Poilly 2013, Melina and Villa 2014, and Canzoneri et al. 2015) or on government debt (see Röhrs and Winter 2015). Moreover, with the exception of Melina and Villa (2014) and Ji and Qian (2015), none of these papers empirically documents that fiscal policy and financial markets are linked.

Our work is also related to several other strands of literature. First, we contribute to the literature that analyzes the consequences of tax liability changes, see the survey by Ramey (2016). So far, the focus of previous papers has been exclusively on the real part of the economy. Our results suggest that tax changes also have an impact on the financial sector.

Second, the results in our paper contribute to the literature that aims at understanding the consequences of prominent tax acts, such as the 1986 TRA and the 2003 JGTRRA, see e.g. Cutler (1988), Poterba (1992), Auerbach and Slemrod (1997), or Auerbach and Hassett (2005, 2006). We document new channels through which these tax acts affect the US economy, which have not been considered by the previous literature.

And last but not least, by documenting that tax changes can lead to large, albeit infrequent, deviations of corporate bond prices relative to the expected default risk, we contribute to the literature that attempts to explain the 'corporate bond puzzle' (see e.g. Collin-Dufresne, Goldstein, and Martin 2001, Elton et al. 2001, and Driessen 2005).

The remainder of this paper is structured as follows. In Section 2, we describe our data for tax changes and excess bond premia. In Section 3, we discuss our estimation strategy. The responses of excess bond premia and of other measures of credit spreads to tax changes are shown in Section 4. In Section 5, we analyze whether tax changes also have an impact on measures of the condition of intermediaries' balance sheets. For this purpose, we take a more disaggregate view and analyze the impact of personal and corporate income tax changes separately. Moreover, we also disentangle the impact of specific tax acts. Finally, Section 6 concludes.

## 2 Data: Tax Changes and Credit Spreads

This paper documents a novel link between tax changes and credit spreads. In this section, we describe how changes in tax liabilities and credit spreads are measured.

## 2.1 Identification of Exogenous Tax Shocks: The Romer and Romer (2010) Narrative Approach

In order to identify the impact of discretionary tax changes, we make use of the Romer and Romer (2010) narrative record of federal tax changes in the US between 1945 and 2007. Romer and Romer (2010) classify each tax act according to four categories of motivation: spending-driven (e.g. due to war), countercyclical, deficit-driven (to reduce inherited budget deficits), and to raise long-run growth (e.g. improve incentives, reduce inefficiencies). They argue that spending-driven and countercyclical tax changes are endogenous because they are correlated with other forces affecting output in the short run. Tax events that belong to the other two categories, on the other hand, can be seen as exogenous, since they are not motivated by current or prospective short-run economic conditions. Using this classification, Romer and Romer (2010) construct a quarterly dataset of exogenous tax changes.<sup>7</sup> The size of each tax change is defined as its impact on annual tax liabilities in percent of current GDP. The dataset contains 54 exogenous tax liability changes that are the result of 35 tax acts between 1945 and 2007. A brief remark regarding the measurement of the tax changes is in order. For various reasons, the narrative measure might be subject to measurement error.<sup>8</sup> In Appendix C, we discuss how we correct for the measurement error inherent in the narrative measure. As a result of this procedure, we measure the change in tax liabilities/GDP, which we denote by  $\Delta\text{tax}_t$ .  $\Delta\text{tax}_t$  can therefore be interpreted as a change in the average tax rate of the economy.<sup>9</sup>

We only use those tax liability changes that are ‘unanticipated.’ We will discuss the reason for this in greater detail in the following paragraph.

**Avoiding anticipation effects.** When looking at tax changes, it is important to be aware of anticipation effects. This has, among others, been pointed out by Mertens and Ravn (2012), Leeper, Richter, and Walker (2012), and Yang (2007). In our context, the issue of anticipation effects is even more pressing, since we work with market-determined interest rates, which can react instantaneously to news about future tax changes.

Therefore, we only use the exogenous tax changes in the Romer and Romer (2010) dataset that were ‘unanticipated.’ Our definition is inspired by Mertens and Ravn (2012), who classify a tax change as unanticipated if there are no more than 90 days between the announcement and implementation dates (where the announcement date is the day on which the tax became a law, i.e. when it was signed). For our purpose, we are even stricter and only treat a tax change as unanticipated if the implementation and announcement dates are less than 30 days apart.<sup>10</sup> As a robustness check, we also create a time

<sup>7</sup>See also their companion paper Romer and Romer (2009).

<sup>8</sup>Mertens and Ravn (2013) discuss several reasons why narrative shocks could be misreported. Narrative measures may for example be censored because large innovations are more likely to be measured. In addition, the narrative record may misreport exogenous, unanticipated tax changes as either endogenous or anticipated. Measurement error could also occur because the size of the innovations  $\Delta\text{tax}_t$  is mismeasured, e.g. because of wrong scaling.  $\Delta\text{tax}_t$  is computed using available projections of changes in tax liabilities. These projections assume that the tax base remains constant following a tax change. Clearly, this is not the case, since GDP, and therefore the tax base, decline following a tax increase. Stock and Watson (2012), Mertens and Ravn (2013), and most recently Hebous and Zimmermann (2015) all argue that narrative series are likely to suffer from severe measurement problems.

<sup>9</sup>Instead, Romer and Romer (2010) normalize tax liability changes by the GDP prevailing in the quarter in which the tax change occurs.

<sup>10</sup>Note that for the announcement date we have the exact day, whereas for the implementation date we only know the

series that follows the Mertens and Ravn (2012) definition. It turns out that our results are robust to different definitions of unanticipated tax acts. The results can be found in an Online Appendix.<sup>11</sup>

In that context, it is important to note that we use a slightly different timing convention than Romer and Romer (2010) and Mertens and Ravn (2012). Specifically, Romer and Romer (2010) assign a tax change that takes place in the second half of a quarter to the following quarter. As we are dealing with interest rates, which are expected to react even within the same day, we assign every tax change to the quarter it actually happened in.<sup>12</sup>

As a result of these adjustments, our dataset contains 21 unanticipated tax liability changes over the period 1945 - 2007 that derive from 21 different tax events. Exact details about the timing, the size, and the categorization of every tax change are given in Table 1 and Table 2 in Appendix A. Figure 1 presents the data.

Finally, we test whether there are signs that our series of unanticipated tax events was nevertheless anticipated by the market. For this purpose, we construct the yield spread between Treasuries and municipality bonds, using data from Leeper, Richter, and Walker (2012). Treasuries are subject to federal income taxation, whereas municipality bonds are not. The spread between the two bonds should therefore reflect market expectations of the present value of tax changes over the maturity of the bond. If tax changes were anticipated, we should find that their incidence can be predicted by the municipality bond spread. However, this is not the case. Specifically, we cannot reject the null hypothesis that the municipality spread does not Granger cause our narrative series of unanticipated tax shocks. Nevertheless, for those tax acts that turn out to be particularly relevant for our results, we will discuss the presence of anticipation effects separately.

## 2.2 Excess Bond Premia and Their Interpretation

Data on excess bond premia are taken from Gilchrist and Zakrajšek (2011) for financial firms and from Gilchrist and Zakrajšek (2012) for non-financial firms.<sup>13</sup> Gilchrist and Zakrajšek (2011, 2012) construct individual corporate bond spreads for non-financial and for financial firms using micro-level data for a large sample of US firms. See also Gilchrist, Yankov, and Zakrajšek (2009) for a similar approach. For each firm, the spread is defined as the difference in the yield of senior, unsecured bonds and a synthetic risk-free asset. The synthetic risk-free asset is constructed such that its cash flows exactly match the payment structure of the corresponding corporate bond.

Gilchrist and Zakrajšek (2011, 2012) then decompose the spread for each firm into a component that captures the countercyclical movements in default risk and a procyclical residual, which measures the willingness of the market to accept default risk. This latter component is labeled as excess bond premium. In the following, we denote the average excess bond premium for non-financial firms as EBP

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month. Assuming that the implementation always happened at the beginning of the month, we also count those tax acts as ‘unanticipated’ for which the implementation month is in the month after the announcement date. In a robustness check, we only count those tax acts for which the announcement month and the implementation month are the same. Reassuringly, this does not change our results.

<sup>11</sup>The Online Appendix is available here: <http://www.econ.uzh.ch/faculty/winter.html>.

<sup>12</sup>In Section 5, we distinguish between personal and corporate income tax changes. For this purpose, we use the dataset by Mertens and Ravn (2013) and therefore follow their timing convention.

<sup>13</sup>We thank the authors for making their data publicly available.

and the average excess bond premium for financial firms as FBP. EBP is available from 1973Q1 onwards. The time series for FBP starts in 1985Q1.

Relative to other corporate bond spreads that are commonly used in the literature, such as the spread between yields of Aaa-rated corporate bonds and Treasuries, excess bond premia have two key advantages. First, they are constructed using micro-level data, whereas other corporate bond spreads are typically based on aggregate data only. The aggregate approach makes it impossible to compare the payment structure, maturity etc. of the financial instruments. EBP and FBP, on the other hand, are not subject to this maturity mismatch.

The second key advantage is that excess bond premia can be interpreted as evidence for the existence of ‘financial frictions,’ whereas corporate bond spreads alone cannot. As noted by Philippon (2009), even in the absence of financial frictions (i.e. in a world in which the Modigliani-Miller Theorem holds), the prices of corporate bonds, and therefore corporate bond spreads, depend on default risk. The high predictive power of excess bond premia, in particular of EBP, for real economic activity can be interpreted as further evidence for the fact that excess bond premia signal the strength of ‘financial disruptions,’ see Gilchrist and Zakrajšek (2012). López-Salido, Stein, and Zakrajšek (2016) and Krishnamurthy and Muir (2016) also provide evidence for the predictive power of credit spreads for real economic activity.

In particular, Gilchrist and Zakrajšek (2011, 2012) argue that there is a strong negative correlation between the return on assets of the financial sector and both EBP and FBP. We can confirm this by regressing EBP or FBP on the return on assets of the US financial sector and a constant.<sup>14</sup> For EBP, the estimated coefficient for the return on assets is  $-0.56$ , with a standard error of  $0.066$  ( $R^2 = 0.32$ ). Our estimates reveal an even tighter link between FBP and return on assets. Here, the estimated coefficient is  $-0.64$ , with a standard error of  $0.072$  ( $R^2 = 0.43$ ). These correlations suggest that there is a close connection between financial intermediaries’ balance conditions, as measured by the return on assets, and excess bond premia.

The link between intermediaries’ balance sheet conditions and excess bond premia arises in models in which corporate bonds are priced by financial intermediaries. See e.g. Xiong (2001), He and Krishnamurthy (2013), and Brunnermeier and Sannikov (2014) for recent papers that study the consequences of intermediary asset pricing.<sup>15</sup> These papers are, in part, motivated by the large empirical literature that studies the level and the variation of corporate bond spreads, concluding that spreads appear to be too high to be explained by a household pricing kernel (see e.g. Collin-Dufresne, Goldstein, and Martin 2001).<sup>16</sup> Other models of financial intermediation also assume that savers, or households, cannot buy assets directly, see e.g. Gertler and Kiyotaki (2010). A common feature of models in which financial intermediaries price assets is that their willingness to hold (risky) assets is linked to their net worth position. This connection typically arises because of an agency problem between intermediaries and

<sup>14</sup>For a precise definition of the return on assets, we refer to Appendix A.

<sup>15</sup>See Brunnermeier, Eisenbach, and Sannikov (2012) for a survey of the literature.

<sup>16</sup>With respect to corporate bonds, the assumption that they are almost exclusively held by financial intermediaries is also borne out by the data. In most years for which data from the US Financial Accounts is available, the volume of corporate and foreign bonds held by the financial sector is about three to four times larger than the volume owned by households and nonprofit organizations. Compared to this gap, the difference in the volume of corporate equity held by the financial sector relative to the household sector (around 30 percent) appears to be small. See Tables L.101 and L.108 of the Financial Accounts.



households, who are the ultimate suppliers of funds. While the specific details differ across models, a common assumption that is shared by many of them is that there is moral hazard on the side of the intermediary, as in Holmstrom and Tirole (1997). As a result, households require that the intermediary has a sufficient stake in the business in order to prevent shirking. When the incentive compatibility constraint for intermediaries becomes binding, their effective risk aversion goes up, and the risk premium they require therefore increases. Adrian, Moench, and Shin (2010), Adrian and Shin (2010a, 2010b), and Adrian, Colla, and Shin (2012) provide empirical evidence for the importance of financial intermediaries' balance sheet conditions for their effective risk-bearing capacities and therefore also for asset prices in general.

These theories therefore predict that excess bond premia are tightly linked to financial intermediaries' balance sheet conditions, a finding that is confirmed by our empirical evidence stated above. Given the importance of intermediaries' balance sheet conditions for both EBP and FBP, it is not surprising that both types of excess bond premia comove tightly, as indicated by Figure 2. Strikingly, both EBP and FBP increase significantly prior to or during most recessions that occurred during our sample period.

However, Figure 2 also reveals that the correlation between EBP and FBP is not perfect. Two counterexamples are the 1990-1991 and the 2001 recession. Gilchrist and Zakrajšek (2011) discuss the differences between these two economic downturns in greater detail. The fact that EBP and FBP differ to some extent thus suggests that there must be other forces driving the two excess premia, in addition to intermediaries' balance sheet conditions. After all, the  $R^2$  for the regressions of EBP/FBP on the return on assets was well below one. However, it goes beyond the scope of our paper to understand all determinants of EBP and FBP. Before we analyze the impact of tax changes on EBP and FBP, we will describe our estimation procedure in the next section.

### 3 Estimation

In this section, we discuss the details regarding our estimation procedure. Specifically, we use VAR model to estimate the impact of tax changes.

**Baseline VAR.** Following Favero and Giavazzi (2012), Mertens and Ravn (2011, 2012), and Cloyne (2013), we estimate the following reduced-form VAR:

$$y_t = \sum_{i=1}^p A_i y_{t-i} + \sum_{j=0}^s B_j x_{t-j} + D + Et + u_t, \quad (1)$$

where  $y_t$  is the vector of endogenous variables, and the exogenous variable  $x_t$  is given by  $\Delta \text{tax}_t$ . In the exogenous part of the VAR, we also include a constant  $D$  and a linear time trend with coefficient matrix  $E$ .

Using our reduced-form VAR, we can compute the dynamic multipliers, i.e. the responses of the endogenous variables to exogenous tax liability changes. Following Lütkepohl (2006), Chapter 10, we rewrite the reduced form as:

$$A(L)y_t = B(L)x_t + u_t,$$

using the following definitions:  $A(L) := I_K - A_1 L - \dots - A_p L^p$  and  $B(L) := B_0 + B_1 L + \dots + B_s L^s$ . The

final form of the system is then given by

$$y_t = D(L)x_t + A(L)^{-1}u_t,$$

where  $D(L) := A(L)^{-1}B(L)$  is the dynamic multiplier.

We estimate the system given in Specification 1 using quarterly data. The vector  $y_t$  consists of the logarithm of GDP, nondurables consumption (including services), durables consumption, and private investment. We divide all variables by their respective deflator and by population. In addition, we also include the logarithm of hours worked and the ratio of federal tax revenues/GDP. Later, we will augment the system with additional endogenous variables, such as e.g. measures of excess bond premia. A detailed description of all variables is provided in Table 3 in the Appendix.

Note that the concept of exogeneity imposed by Romer and Romer (2010) for the selection of tax liability changes does not necessarily correspond to the definition of exogeneity applied in Specification 1. The econometric definition of exogeneity requires that past changes of observable variables have no predictive power for tax changes. An additional requirement is that tax changes should not contemporaneously respond to other variables. The first assumption can be formally tested. Romer and Romer (2010) and Mertens and Ravn (2012) analyze whether observable variables have predictive power for tax liability changes and conclude that there is no strong evidence for predictability. The second requirement is untestable. However, as noted by Mertens and Ravn (2011), “legislative lags make it very likely that contemporaneous causality runs from changes in tax legislation to observables and not vice versa” (p. 29).

Also note that the results from reduced-form Specification 1 should be interpreted as the (average) effect of all exogenous tax changes included in the narrative. The advantage of Specification 1 is that it can also be used to decompose this average effect by studying the contribution of individual tax acts or specific groups of tax changes. This will be done in Section 5, where we will isolate the effects of corporate and personal income tax changes using information from Mertens and Ravn (2013). Moreover, we will adopt the ‘dummy variable approach’ applied by Ramey and Shapiro (1998) and Burnside, Eichenbaum, and Fisher (2004) to separate the impact of specific tax acts. Using a similar reduced-form specification, Ramey and Shapiro (1998) and Burnside, Eichenbaum, and Fisher (2004) use narrative measures as exogenous variables in order to analyze government spending shocks, see also Ramey (2011).<sup>17</sup>

We set the lag length for the endogenous variables,  $p$ , to 3, as suggested by the Akaike information criterion. Our results are robust to a longer lag structure. As discussed in Appendix C, we set  $s = 1$ , which determines the number of periods during which a narrative tax shock  $\Delta\text{tax}_t$  affects the system of endogenous variables.

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<sup>17</sup>Of course, the structural coefficients cannot be identified from the reduced form without further assumptions, see e.g. Lütkepohl (2006). Stock and Watson (2012) and Mertens and Ravn (2013) develop an alternative approach, in which the narrative measures are used as instrumental variables to identify the structural shocks. Stock and Watson (2008) compare the strengths and the weaknesses of the reduced form and the instrumental variable approach. In this context, one should also note that tax narratives have been shown to be weak instruments, see e.g. Hebous and Zimmermann (2015) and Ramey (2016). Ramey (2016) argues that weak instruments lead to a downward bias, implying that the ‘true’ tax multipliers might be even larger. The impact of weak instruments in empirical macroeconomics more generally is analyzed by Montiel Olea, Stock, and Watson (2012) and by Hebous and Zimmermann (2015).

In the following, we will refer to Specification 1 as our baseline VAR. In Figure 3, we use Specification 1 and plot the effect a positive tax shock on the endogenous variables.<sup>18</sup> The impulse responses are standard and confirm the findings from the previous literature using the Romer and Romer (2010) narrative identification.

## 4 The Impact of Tax Changes on Excess Bond Premia

In this section, we present our main results. We demonstrate that increasing tax liabilities/GDP leads to increases in excess bond premia. We also discuss potential explanations for our findings.

We first analyze the impact of tax liability changes on excess bond premia. Technically, we proceed as follows. Using Specification 1, augmented by either EBP or FBP, we find that a rise in tax liabilities/GDP by one percentage point increases excess bond premia by between 0.8 and 1.8 percentage points, depending on whether we consider FBP or EBP, see Figure 4. While the shape of the responses for EBP and FBP is qualitatively very similar, the peak of the response is higher for EBP. As already noted above, EBP and FBP are highly, but not perfectly correlated, implying that they contain, to some extent, different information. It is therefore not surprising that the impulse responses for the two excess bond premia are not identical.

In sum, independent of the exact measure, there is robust evidence for the fact that an increase in tax liabilities/GDP leads to tighter financial frictions, which makes it more expensive for firms to obtain funds via the corporate bond market. In the following, we would like to discuss two explanations for the impact of tax changes on excess bond premia. It could e.g. be that the case that the link between tax changes and excess bond premia simply arises because of a differential tax treatment of interest payments between corporate bonds and government bonds. As described in Elton et al. (2001), interest payments on corporate bonds are taxed at the state level, whereas interest payments on government bonds are not. This difference is inconsequential for our results, since we study changes in *federal* tax laws, which treat both bonds in the same way. Higher observed spreads can therefore not be explained by the nature of the considered tax changes.

Another potential explanation is the trade-off theory, according to which corporate income tax changes are the main determinant of the equity-debt trade-off faced by firms. The reason is that debt payments are exempt from corporate income taxation, whereas equity payments are not. Firms then face a trade off between reducing tax payments and increasing debt, which also increases expected default.<sup>19</sup> The trade-off theory cannot be the sole driver of our results, since, as we will show later, not only corporate, but also personal income tax adjustments lead to an increase in excess bond premia.

In the remainder of this paper, we will interpret our observation that an increase in taxes leads to higher excess bond premia as evidence for a tightening of financial frictions. This interpretation is motivated by the close link between financial intermediaries' balance sheet conditions and excess bond premia that we documented in Section 2.2. In a next step, we analyze the impact of tax changes on other credit spreads, such as the spread between Aaa-rated corporate bonds and Treasuries. This different set

<sup>18</sup>We use asymptotic standard errors with a small-sample correction. Bootstrapping standard errors with 10'000 replications as in Mertens and Ravn (2011) leads to identical results.

<sup>19</sup>See Tirole (2006) for an overview of the static theory and Strebulaev and Whited (2011) for the dynamic version.

of credit spreads might be informative about other channels, such as changes in liquidity premia, which allows us to discuss alternative explanations for the link between tax changes and credit conditions.

**Impact of tax changes on other credit spreads.** We now analyze whether tax changes also affect other widely used credit spreads, such as the spread between yields of Aaa-rated corporate bonds and Treasuries, and the spread between Baa- and Aaa-rated corporate bonds.<sup>20</sup> This allows us to gain insights into other possible drivers of the tightening of financial frictions, which will not be the focus of this analysis. To test the impact of tax changes on our alternative set of credit spreads, we include them one by one in Specification 1, instead of EBP/FBP. Interestingly, as we show in the Online Appendix, all of these credit spreads rise in response to an increase in taxes, although the size of the response is quantitatively smaller, compared to the response of EBP or FBP that we documented in the previous subsection. Increasing tax liabilities/GDP by one percentage point raises the Aaa-Treasury and the Baa-Aaa spread by around 0.3 percentage points, and the Baa-Aaa spread by around 0.5 percentage points.

Following Krishnamurthy and Vissing-Jorgensen (2012), we might interpret the Aaa-Treasury spread as an indicator for the value of liquidity. Aaa-rated corporate bonds are similar to Treasuries in the sense that their default risk is close to zero, but they are less liquid. Along the same lines, we might interpret the Baa-Aaa spread as a measure for the value of safe assets, since both Baa- and Aaa-rated corporate bonds share the same liquidity properties, but Baa-rated corporate bonds have a higher default risk.<sup>21</sup> Our finding that increasing taxes raises credit spreads could then be driven by an increase in the liquidity and the safety premium associated with Treasuries, which, in turn, could be due to the fact that a tax increase reduces government debt, and therefore the supply of government bonds, as shown by Mertens and Ravn (2013). Indeed, Krishnamurthy and Vissing-Jorgensen (2012) document that both the liquidity and the safety premium of Treasuries is inversely related to the public debt/GDP ratio in the US.

We therefore conclude by noting that in addition to intermediaries' balance sheet conditions, there might be other channels that explain the transmission of tax adjustments to credit spreads, notably changes in the supply of government bonds. We will leave it to future research to disentangle the role of balance sheet conditions from other channels. We would like to stress that changes in the liquidity and safety premium are also a consequence of financial frictions.<sup>22</sup> Therefore, independent of the precise channel, our results clearly indicate that tax changes affect financial frictions.

<sup>20</sup>Ji and Qian (2015) document an impact of tax liability changes on bank spreads.

<sup>21</sup>However, the increase in the Baa-Aaa spread could just be a by-product of the adverse impact of taxes on the economic environment, which raises the default risk of Baa-rated corporate bonds, relative the default risk of Aaa-rated corporate bonds.

<sup>22</sup>Changes in government debt can only affect the liquidity and the safety premium if financial intermediaries cannot create substitutes that come close to government bonds, which indicates the presence of financial frictions.

## 5 The Impact of Tax Changes on Financial Frictions, Financial Intermediaries, and Excess Bond Premia: Empirical Evidence

In the previous section, we documented that tax changes affect financial frictions, as measured by excess bond premia. In this section, we want to understand why this is the case. In order to find an answer to this question, we will search for those tax acts that jointly affect excess bond premia and the return on assets of financial intermediaries. This strategy is motivated by the fact that intermediaries' balance sheet conditions are an important determinant of excess bond premia, as discussed in Section 2.2. The advantage of our approach is that it allows to pinpoint exactly through which channels tax changes affect financial intermediaries' balance sheet conditions and therefore financial frictions. It is important to note that our analysis does not aim at identifying *all* possible channels through which tax changes might impact financial frictions but rather to shed light on two specific channels working through financial intermediaries' balance sheets.

From a technical point of view, we face the following challenge. Given that there are many determinants that influence balance sheets of the financial sector, our previous assumption that all tax changes are identical with respect to the size of their effects, and the assumption that their dynamics can be estimated using the same system appears to be overly restrictive. We circumvent this problem by allowing for heterogeneity across tax changes. In a first step, we distinguish between the two most important subgroups of tax changes, personal and corporate income tax adjustments. Together, both groups account for 75 percent of total federal tax revenues (Mertens and Ravn 2013). Hence, we estimate a separate VAR for personal and corporate income tax changes, thereby allowing for different dynamic responses to an adjustment of taxes in one of the two groups.

Within each group, tax changes differ substantially with respect to their size, see Figure 5. In a second step, we therefore investigate to what extent specific tax changes influence the aggregate impact of personal and corporate income tax changes that we identified in the first step. We do so by introducing dummy variables for all tax acts that belong to the post-1984 period, for which we have information on the excess bond premia of both financial and non-financial firms. These tax acts are the 1986 Tax Reform Act (TRA), the 1987 Omnibus Budget Reconciliation Act (OBRA), the 1990 Omnibus Budget Reconciliation Act (OBRA), and the 2003 Jobs and Growth Tax Relief Reconciliation Act (JGTRRA). Some of these tax acts are also among the most significant tax acts in the entire sample. In this second step, we follow the 'dummy variable approach' employed by Ramey and Shapiro (1998) and in particular by Burnside, Eichenbaum, and Fisher (2004).

**Measuring the impact of personal and corporate income tax changes.** Using the Romer and Romer (2010) data as a source, Mertens and Ravn (2013) construct separate time series of exogenous, unanticipated tax changes for corporate income taxes and personal income taxes. Corporate income tax changes include adjustments in depreciation allowances, investment tax credits, and marginal tax changes. Personal income tax changes include marginal income tax adjustments, adjustments in capital gain and dividend taxes, and various deductions and tax credits. In order to distinguish between the impact of personal and corporate income tax changes, we apply the Mertens and Ravn (2013)

methodology to our data. The resulting categorization of every single tax change is given in Table 2 in Appendix A.

Similar to our baseline specification, we estimate the following VAR:

$$y_t = \sum_{i=1}^p A_i y_{t-i} + \sum_{j=0}^s B_j x_{t-j} + D + Et + u_t. \quad (2)$$

where  $x_t$  is now given by either  $\Delta \text{tax}_t^{PI}$  or  $\Delta \text{tax}_t^{CI}$ , depending on whether we are interested in estimating the impact of an adjustment in personal income taxes (PI) or corporate income taxes (CI). As before, we include a constant  $D$  and a linear time trend with coefficient matrix  $E$  in the exogenous part of the VAR, and set  $p = 3$  and  $s = 1$ . All our following results are robust to including more lags.

We modify the vector  $y_t$  of endogenous variables by replacing the variable tax revenues/GDP with the average personal income tax rate (APITR) and the average corporate income tax rate (ACITR). We follow Mertens and Ravn (2013) and define:

$$\text{APITR}_t = \frac{\text{Personal Current Taxes}_t + \text{Contributions to Govt. Social Insurance}_t}{\text{Personal Taxable Income}_t}$$

$$\text{ACITR}_t = \frac{\text{Taxes on Corporate Profits}_t}{\text{Corporate Profits}_t}$$

It is important to note that  $\Delta \text{tax}_t^{PI}$  and  $\Delta \text{tax}_t^{CI}$  are positively correlated, since, for most tax events,  $\Delta \text{tax}_t^{PI}$  and  $\Delta \text{tax}_t^{CI}$  are changed in the same direction. This correlation may give rise to an omitted variable bias if we incorporate only  $\Delta \text{tax}_t^{PI}$  or  $\Delta \text{tax}_t^{CI}$  in Specification 2. Fortunately, we are able to assess the strength of the omitted variable bias by analyzing the cross-responses, i.e. the response of APITR (ACITR) in Specification 2 to  $\Delta \text{tax}_t^{CI}$  ( $\Delta \text{tax}_t^{PI}$ ). If the cross-responses are insignificant, then the impact of the omitted variable is limited.

The results are shown in Figure 6. The left panel displays the response of APITR to  $\Delta \text{tax}_t^{CI}$ . Although it increases, it is not significantly different from zero. The same is true if we consider the response of ACITR to  $\Delta \text{tax}_t^{PI}$ , shown in the right panel of Figure 6. Given that all cross-responses are insignificant, we conclude that the omitted variable problem should not bias our results significantly.<sup>23</sup>

In order to further alleviate potential concerns regarding the presence of an omitted variable bias, we also include *both*  $\Delta \text{tax}_t^{PI}$  and  $\Delta \text{tax}_t^{CI}$  into Specification 2. All of our results survive this test, as outlined in greater detail in an Online Appendix. Hence, we conclude that our results are not biased because we omit either personal or corporate income tax changes when using either  $\Delta \text{tax}_t^{CI}$  or  $\Delta \text{tax}_t^{PI}$  separately.

Finally, we correct for the measurement error inherent in the narrative measures for  $\Delta \text{tax}_t^{CI}$  and  $\Delta \text{tax}_t^{PI}$  by rescaling our impulse responses such that ACITR (respectively APITR) increases by one percentage point at the peak, as described in Appendix C.

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<sup>23</sup>This test is inspired by Mertens and Ravn (2013), who separate the impact of corporate and personal income tax changes by assuming that a change in  $\Delta \text{tax}_t^{PI}$  affects only APITR on impact, but not ACITR, and vice versa. It tests the recursivity assumption employed by Mertens and Ravn (2013) to separate the impact of personal and corporate income tax liability changes.

## 5.1 Personal Income Taxes and Excess Bond Premia

We start by analyzing the impact of personal income tax changes on excess bond premia. In line with Specification 2, we estimate the following VAR:

$$y_t = \sum_{i=1}^p A_i y_{t-i} + \sum_{j=0}^s B_j \Delta \text{tax}_{t-j}^{PI} + D + Et + u_t. \quad (3)$$

The vector of endogenous variables  $y$  consists of our baseline variables (including APITR and AC-ITR). A vector of constants  $D$  and a deterministic time trend with coefficient matrix  $E$  are also included. We set  $p = 3$  and  $s = 1$ .

The responses of EBP and FBP to an adjustment in personal income taxes are shown in Figure 7. Both excess bond premia rise after an increase in personal income taxes. In particular the response of EBP is sizable and highly significant, whereas the response of FBP is insignificant if we use a 95 percent confidence interval. Differences in the responses between EBP and FBP suggest that the two types of excess bond premia contain, to some extent, different information. In this context, recall our discussion in Section 2.2.

**How do personal income tax changes affect excess bond premia?** We now turn to the question of how personal income tax changes affect excess bond premia. We will argue that balance sheet conditions of financial intermediaries are important for the transmission of personal income tax changes, a finding that is consistent with our discussion in Section 2.2, where we presented evidence for the importance of intermediaries' balance sheet conditions in explaining excess bond premia. Specifically, we will show that personal income taxes have an impact on stock prices, which, in turn, account for a significant part of intermediaries' assets.

Our argument will be structured as follows. We will start by showing that personal income tax changes have an impact on stock market returns, a finding that is consistent with the tax capitalization hypothesis, according to which an unexpected change in the taxation of income from dividends and capital gains affects stock prices and therefore stock returns (see e.g. Sialm 2009 for recent evidence). According to Sialm (2009), the 2003 JGTRRA had the largest impact on effective tax rates for dividends and capital gains. Excluding this tax act from our sample should therefore attenuate the responses of stock market returns. If our hypothesis is true, we should also see that the return on assets of financial intermediaries only responds to the 2003 JGTRRA, but not to other tax events. Finally, to the extent that intermediaries' balance sheet conditions drive excess bond premia, they should respond to the 2003 JGTRRA only. We will show that all of these effects are indeed borne out by the data. We will interpret our findings as strong evidence for the fact that personal income tax changes affect excess bond premia via stock market returns and their impact on the profitability of the financial sector. The 2003 JGTRRA is therefore key for explaining the overall impact of personal income tax changes.

**Personal income tax changes and stock market returns.** We start by analyzing the general relationship between stock market returns and personal income tax changes. In order to do so, we augment Specification 3 by adding one of the following three stock market variables: excess market return, price/dividend ratio, and the cyclically adjusted price/earnings ratio.<sup>24</sup>

<sup>24</sup>Data on the price/dividend ratio and the cyclically adjusted price/earnings ratio are available on Robert Shiller's

In the first panel of Figure 8, we plot the impulse response of the excess stock market return to an increase in the personal income tax rate by one percentage point. The excess stock market return falls by more than 30 percentage points on impact, and starts rising immediately afterwards back to its pre-tax level. The sharp drop in the excess stock market return is driven by a decline in equity valuations, as indicated by the response of the price/dividend ratio and the cyclically adjusted price/earnings ratio, which decrease by five and two percentage points respectively.

The response of stock prices is consistent with the predictions of the ‘tax capitalization hypothesis’ (see e.g. Sialm 2009) for an unexpected increase in dividend/capital gain taxation. According to this hypothesis, stock prices immediately drop after an unexpected increase in dividend/capital gain taxation, even if dividends are not affected. This is because investors are willing to pay less for stocks, so that their after-tax return is unaffected by the tax increase. Additional evidence for the importance of dividend taxes for stock prices is presented by McGrattan and Prescott (2005), who argue that the fall in the average marginal dividend tax rate between 1960 and 2000 can account for the increase in equity prices during the same period.

In the following, we show that the response of stock markets to personal income tax adjustments is mainly driven by the 2003 JGTRRA. We argue that this finding is perfectly consistent with the tax capitalization hypothesis, since the 2003 JGTRRA constituted the largest change for capital gains and dividend taxes in the post-1970 sample of tax events. We begin by briefly summarizing the dividend and capital gain tax changes introduced by the 2003 JGTRRA.

**The 2003 JGTRRA.** Calculations made by Sialm (2009) (see Figure 1 in his paper) reveal that the 2003 JGTRRA had a massive impact on dividend tax rates. Among other measures, the 2003 JGTRRA reduced the dividend tax rate for qualified dividends, relative to the ordinary income tax rate. The effective reduction was substantial for all income brackets, including the top. For households in the highest income bracket, the marginal tax on dividend income fell from almost 40 to 15 percent. This decline is substantial, compared to other tax acts.<sup>25</sup> In addition to dividend taxes, the 2003 JGTRRA also reduced the marginal tax rate on capital gains from 20 to 15 percent.

The quantitative importance of the 2003 JGTRRA is also visible from Figure 5, where we plot the narrative measure for  $\Delta\text{tax}^{PI}$  along with  $\Delta\text{tax}^{CI}$ . With a decrease in personal income tax liabilities of more than one percent relative to the personal income tax base, the 2003 JGTRRA is by far the largest personal income tax change in the post-1970 period. In the following, we analyze the implications of the 2003 JGTRRA for stock prices in greater detail.

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webpage: <http://www.econ.yale.edu/~shiller/data.htm>, retrieved on May 19, 2015. The excess stock market return is defined as the (value-weighted) stock market return (including dividends) of the New York Stock Exchange minus the return on short-run (3 months) T-Bills.

<sup>25</sup>Notable examples of other tax acts that affected only individual income tax rates in the post-1970 period, which is the time span that we are focusing on in this section, are the Economic Recovery Tax Act (ERTA) of 1981 and the TRA of 1986. However, the calculations in Sialm (2009) show that both tax acts only have a small negative impact on the marginal dividend tax rate, compared to the 2003 JGTRRA. With respect to the marginal tax rate on long-run capital gains, Sialm (2009) reports a small negative effect for the 1981 ERTA only. The 1986 TRA even increased the marginal tax rate on long-run capital gains. This is because the 1986 TRA broadened the capital income tax base considerably, thereby repealing many opportunities to deduct taxes. Auerbach and Slemrod (1997) provide a complete description of the 1986 TRA.



**The importance of the 2003 JGTRRA for stock markets.** In order to analyze the importance of the 2003 JGTRRA for the response of stock market returns, we isolate the 2003 JGTRRA from the other post-1970 personal income tax changes considered by the Mertens and Ravn (2013) narrative. More specifically, we estimate the following system:

$$y_t = \sum_{i=1}^p A_i y_{t-i} + \sum_{j=0}^s B_j^o \Delta \text{tax}_{t-j}^{PI,o} + \sum_{j=0}^s B_j^J \Delta \text{tax}_{t-j}^{PI,J} + D + Et + u_t, \quad (4)$$

where  $\Delta \text{tax}^{PI,o}$  denotes all unanticipated personal income tax changes other than the 2003 JGTRRA and  $\Delta \text{tax}^{PI,J}$  denotes the 2003 JGTRRA. We are interested in  $D^{PI,o}(L) := A(L)^{-1}B^o(L)$ , the dynamic multiplier associated with  $\Delta \text{tax}^{PI,o}$ . We again include a constant and a linear time trend in the deterministic part of the VAR.

We would like to stress that when estimating Specification 4, we are only interested in the sign and the significance of the multipliers, but not in their magnitude.<sup>26</sup> Our specification is thus similar to the dummy variable approach used in Ramey and Shapiro (1998) and Burnside, Eichenbaum, and Fisher (2004). When interpreting the sign of the estimated dynamic multipliers, it is important to keep in mind that we compute the effect of an increase in personal income tax liabilities, even if we consider the impact of the 2003 JGTRRA alone, which actually constituted a reduction in tax liabilities. We do this in order to be consistent with the rest of our analysis. Due to the linearity of the VAR, this only has an effect on the sign of the dynamic multipliers.

To estimate the dynamic multiplier for the price/dividend ratio, for the cyclically adjusted price/earnings ratio, and for the excess stock market return, we add each of these time series to our system separately as an additional endogenous variable. The results for  $\Delta \text{tax}^{PI,o}$  are shown in Figure 9.

As a comparison of Figures 8 and 9 makes evident, excluding the 2003 JGTRRA (i.e. considering the response of  $\Delta \text{tax}^{PI,o}$ ) renders the response of the price/dividend ratio insignificant, while the response of both the price/earnings ratio and the excess stock market return become insignificant. We therefore conclude that the 2003 JGTRRA is pivotal in explaining the responses of equity valuations and equity returns to personal income tax changes. This confirms that dividend/capital gain taxes drive stock returns.

**The impact of the 2003 JGTRRA on balance sheet conditions of financial intermediaries.** We now turn to the relationship between personal income tax changes and balance sheet conditions of financial intermediaries. Our analysis is motivated by the fact that corporate equity holdings account for a sizable fraction of total assets of financial intermediaries.<sup>27</sup> Given that personal income tax changes affect stock returns, we therefore expect that they also have an impact the return on assets of the financial sector. As our previous analysis has shown that the relationship between personal income tax changes and stock returns is mainly driven by the 2003 JGTRRA, the same should be true for the return on assets of financial intermediaries, according to our hypothesis.

<sup>26</sup>This is because  $\Delta \text{tax}^{PI,o}$  and  $\Delta \text{tax}^{PI,J}$  are potentially subject to different measurement error, rendering a direct comparison of the estimated dynamic multipliers  $D^{PI,o}(L)$  and  $D^{PI,J}(L)$  meaningless anyway.

<sup>27</sup>According to the US Financial Accounts (see Table L.108), holdings of corporate equity account for 17 percent of the total financial asset positions of the US financial sector in 2003. The largest component of total financial assets are loans (28 percent), the core business of the financial industry.

In order to test this hypothesis, we use Specification 4 and include the following variables into  $y$ , the vector of endogenous variables: the return on assets for all financial firms (see Gilchrist and Zakrajšek 2012), the return on assets for commercial banks, which are the largest subgroup of the financial sector, as well as the excess stock market return, as defined above.<sup>28</sup>

In order to save degrees of freedom, we drop all other endogenous variables from our baseline system, with the exception of APITR and ACITR. For this new system, we pick  $p = 6$  for the number of lags for the endogenous variables, based on likelihood ratio tests. With respect to the number of exogenous lags, we keep  $s = 1$ , as before.

As Figure 10 shows, the return on assets for the overall financial sector responds significantly if we consider the 2003 JGTRRA (left panel), whereas we cannot observe any reaction for all other personal income tax changes (right panel). This result thus confirms our hypothesis that personal income tax changes affect balance sheet conditions – as measured by the return on assets – through stock market returns. We find that the response of the return on assets of commercial banks is identical to the response of the return on assets of the overall financial sector. The corresponding figure is therefore omitted.

So far, we have argued that the 2003 JGTRRA is the only personal income tax act that affects balance sheet conditions of financial intermediaries. According to the literature on intermediary asset pricing, which we survey in Section 2.2, balance sheet conditions of financial intermediaries are important determinants of excess bond premia. As a consequence, these risk premia should be affected by the 2003 JGTRRA. In fact, we would expect that the 2003 JGTRRA is the only personal income tax act that affects the effective risk aversion of the financial sector. In the next paragraph, we will show that these two predictions are indeed borne out by the data.

**The link between the 2003 JGTRRA and excess bond premia.** We now return to the relationship between personal income tax events and excess bond premia that we documented earlier. If corporate bonds are indeed priced by financial intermediaries, as suggested by the literature on intermediary asset pricing reviewed in Section 2, the impact of personal income tax changes on excess bond premia should hinge on the 2003 JGTRRA, since, as shown above, only the 2003 JGTRRA leads to a response of the return on assets of financial intermediaries.

In this section, we use Specification 4 to test to what extent the response of excess bond premia, in particular EBP, is indeed driven by the 2003 JGTRRA. As the results in Figure 11 indicate, excluding the 2003 JGTRRA renders the response of EBP insignificant. In contrast, the response to  $\Delta\text{tax}^{PI,J}$ , which measures the impact of the 2003 JGTRRA, is remarkably similar (in terms of shape) to the overall response generated by all personal income tax changes  $\Delta\text{tax}^{PI}$  that we documented earlier using Specification 2. Of course, the level differs markedly, because, as we mentioned above, we cannot interpret the magnitude when we use the dummy variable approach. Note that we do not consider FBP, since as demonstrated above, its response to personal income tax changes is insignificant anyway.

Our findings are also related to a large literature studying the impact of the 2003 JGTRRA on equity valuations and corporate behavior in general, see e.g. the work by Poterba (2004), Auerbach and Hassett (2005, 2006), Chetty and Saez (2006), Brown, Liang, and Weisbenner (2007), Amromin, Harrison, and

<sup>28</sup>The return on assets for commercial banks is calculated using Compustat data. Please refer to Appendix A for further details.

Sharpe (2008), Korinek and Stiglitz (2009), Gourio and Miao (2010, 2011), Anagnostopoulos, Cárceles-Poveda, and Lin (2012), Atesagaoglu (2012), and most recently Yagan (2015). We contribute to this strand of literature by documenting a novel link between the 2003 JGTRRA and equity valuations on the one hand and balance sheet conditions of financial intermediaries and excess bond premia on the other hand. This link implies that the 2003 JGTRRA also had an impact on the cost of debt financing of firms, via the balance sheet conditions of financial intermediaries.

**Discussion: other evidence for the impact of the 2003 JGTRRA on equity valuations.** Our argument hinges on the finding that the 2003 JGTRRA had a positive impact on equity valuations. In the following, we will carefully scrutinize this result. A visual inspection of the time series of the S&P 500 stock market index indeed suggests that share prices rose around the announcement date of the 2003 JGTRRA, see Figure 1 in Amromin, Harrison, and Sharpe (2008). What is further needed in order to argue that this rise is at least partly due to 2003 JGTRRA is that the announcement of the tax act was unanticipated. According to Brown, Liang, and Weisbenner (2007), the tax change moved particularly fast from its first proposal in January 2003 to the signed law in May 2003. In addition, Auerbach and Hassett (2005) mention that the political debate was unpredictable, which created a lot of uncertainty among market participants. Amromin, Harrison, and Sharpe (2008) provide evidence that prior to mid-May 2003, it was still unclear whether any substantial cut in dividend taxes would find a majority.

However, the unexpected announcement of the 2003 JGTRRA is not sufficient to prove an impact of the 2003 JGTRRA on equity valuations, since there might have been other events that also influenced stock prices.<sup>29</sup> It is not possible for us to control for other factors that occurred at the same time, for example by including a time dummy, since this dummy would be perfectly collinear with  $\Delta \text{tax}^{PI,J}$ . Progress can be made by working with firm-level data. Auerbach and Hassett (2005) and Brown, Liang, and Weisbenner (2007), among others, document an impact of the 2003 JGTRRA on stock prices of individual firms. We conclude that there is strong evidence for the impact of the 2003 JGTRRA on equity valuations, and that its impact on excess bond premia therefore explained by the effect changing equity valuations on intermediaries' balance sheet conditions.

## 5.2 Corporate Income Taxes and Excess Bond Premia

In the previous section, we analyzed the link between personal income tax changes and excess bond premia. In this section, we will turn our attention to corporate income tax changes. More specifically, we will show that corporate income tax changes also have an impact on excess bond premia.

Motivated by the fact that intermediaries' balance sheet conditions appear to be an important determinant of excess bond premia, we will examine whether balance sheet conditions of financial intermediaries are also affected by corporate income tax changes. Understanding whether and why tax changes affect balance sheet conditions of the financial sector allows us to shed light on the link between tax adjustments and excess bond premia. Indeed, we will document that an increase in corporate income

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<sup>29</sup>For example, Amromin, Harrison, and Sharpe (2008) mention investors' relief about the resolution regarding the military intervention in Iraq as a potential confounding event that occurred over the same period. However, this argument is inconsistent with evidence provided by Baker, Bloom, and Davis (2016), who show that uncertainty actually increased in the relevant period.

taxes adversely affects the return on assets of commercial banks and of the financial sector in general; a finding that is in line with our results for personal income tax changes.

However, in contrast to our previous findings for personal income taxes, stock market returns do not seem to matter for the transmission of corporate income tax changes to balance sheet conditions of financial firms. Instead, our results suggest that the return on assets declines because banks increase their loan loss provisions. We will document that the rise in loan loss provisions occurs in parallel with the increase in the fraction of non-performing commercial and industrial (C&I) loans, which suggests that the increase in the latter is the reason for the rise in the former, rather than changes in the tax incentives caused by alternations in the deductibility of loan loss provisions.

We then turn to the question why corporate income tax changes affect the fraction of non-performing C&I loans. To answer this question, we check which tax event (or which group of tax events) from our narrative record is able to explain the response in the fraction of non-performing loans, loan loss provisions, and the return on assets simultaneously. We would expect that the response of excess bond premia to changes in corporate income taxes also hinges on this tax shock (or this group of tax shocks) if the banks' balance sheet conditions indeed matter for the transmission of tax changes to excess bond premia.

Our analysis reveals that the 1986 TRA is the sole driver for the response of non-performing loans and loan loss provisions. We further show that the 1986 TRA also has an impact on the return on assets of financial intermediaries and on FBP. EBP also increases, but insignificantly.

Finally, we will analyze how the 1986 TRA could have triggered an increase in the fraction of non-performing loans. One of the main objectives of the 1986 TRA was to 'level the playing field', see Poterba (1992). This required a broadening of the tax base by reducing investment in tax shelters and by abolishing deductions. Losers of the reform were therefore firms in capital-intensive sectors such as mining and heavy industries (see Cutler 1988). We will thus argue that this is a possible channel through which corporate income tax changes affect excess bond premia.

#### **The impact of corporate income tax changes on excess bond premia: aggregate evidence.**

In line with our approach for personal income tax changes, we estimate the following VAR:

$$y_t = \sum_{i=1}^p A_i y_{t-i} + \sum_{j=0}^s B_j \Delta \text{tax}_{t-j}^{CI} + D + Et + u_t \quad (5)$$

The vector of endogenous variables  $y$  consists of our baseline variables (including APITR and ACITR). Again, we include a constant  $D$  and a deterministic time trend with coefficients  $E$ . We set  $p = 3$  and  $s = 1$ , as in the baseline Specification 1. Our results are robust to higher lag orders.

The responses to a one percentage point increase in ACITR are depicted in Figure 12. EBP and FBP increase by around 0.3 and 0.4 percentage points respectively. Compared to the response to personal income tax changes, the response of FBP now appears to be more sizable. As we describe in the Online Appendix, the response of EBP disappears as soon as we additionally control for personal income tax changes  $\Delta \text{tax}^{PI}$  in Specification 5. In principle, this implies that we cannot tell apart whether the response of EBP is driven by personal or corporate income tax changes. As we show in the Online Appendix, whereas the relationship between corporate income tax changes and EBP is not robust to controlling for personal income tax changes  $\Delta \text{tax}^{PI}$ , the response of FBP (as well as all other results that we describe in this section) are robust to corporate income tax changes.

**The impact of corporate income tax changes on balance sheet conditions of the financial sector.** Motivated by the close link between financial intermediaries’ balance sheet condition and excess bond premia that we documented in Section 2.2, we now analyze to what extent corporate income tax changes affect the return on assets of the financial sector.

Our analysis is conducted by incorporating the return on assets for the overall financial sector or the (pre-tax) return on assets for commercial banks, which is the largest subgroup within the financial sector, into Specification 5. It turns out that our results are identical for the return on assets of the total financial sector and of commercial banks. In the following, we will therefore focus on the return on assets for commercial banks. We do so because balance sheet conditions of commercial banks will play a decisive role in the remainder of our analysis.

As Figure 13 reveals, an increase in ACITR by one percentage point reduces the (pre-tax) return on assets for commercial banks by approximately 0.4 percentage points two quarters after the tax increase. The effect fades out quickly. The response is highly significant, as indicated by the narrow 95 percent confidence bands.

Robustness checks reveal that the response of the return on assets is invariant to changes in the lag length for the endogenous variables, but not to changes in the exogenous variables (i.e. the tax narrative). Here, a minimum lag length of  $s \geq 2$  is required to obtain our results, which indicates that it takes (at least) two quarters until the impact of corporate income tax changes on the return on assets of the financial sector becomes visible. In the following, we will therefore set  $s = 2$ . Note that our results for the baseline variables remain unchanged if we set  $s = 2$  instead of  $s = 1$ .

**Why do corporate income tax changes affect balance sheet conditions of the financial sector?** We now turn to the question why corporate income tax changes affect balance sheet conditions of the financial sector. An obvious point that immediately comes to mind is that the return on assets declines because banks need to pay more taxes. If this was correct, then we should only see an effect on the after-tax return on assets, but not on the pre-tax return. This is not the case, as indicated by Figure 13, where we plot both the response of the pre-tax and of the after-tax return on assets for commercial banks. If anything, the response of the pre-tax return on assets is more pronounced (0.4 versus 0.3 percentage points). Hence, we conclude that tax liability changes in the financial sector are not the driver behind the impact of corporate income tax adjustments on banks’ balance sheet conditions.

The second hypothesis that we consider are changes in stock market returns, partly inspired by our previous results for personal income tax changes. Cutler (1988) summarizes theoretical evidence in support of this link, but fails to find a large market response to tax news empirically. If we incorporate the excess stock market return into Specification 5, we do not find a significant response either, as indicated by Figure 14. We therefore conclude that corporate income tax adjustments affect banks’ balance sheet conditions via other channels than equity valuation changes. This result establishes a major difference between the transmission of personal and corporate income tax changes.

We now analyze whether the largest asset position of banks, their loan portfolio, is affected by corporate income tax changes. One could imagine that some of the banks’ borrowers find it more difficult to repay their loans after an increase in corporate income taxes. Through general equilibrium effects, borrowers might suffer either directly or indirectly from higher tax liabilities.

To test the consequences of corporate income tax adjustments for the quality of loans, we use the

Bank Regulatory Database to construct a quarterly time series for the (annualized) provision for loan losses that banks make, relative to their total stock of loans. Data are available starting from the first quarter of 1976.<sup>30</sup> We incorporate the loan loss provisions/loan ratio as an additional endogenous variable into Specification 5.

The impulse response of the loan loss provisions/loan ratio to a one percentage point increase in ACITR is shown in Figure 15. Strikingly, the response of the loan loss provisions/loan ratio appears to be the mirror image of the response of the return on assets for commercial banks. In the second quarter following the tax increase, the loan loss provisions/loan ratio goes up by 0.6 percentage points, whereas the pre-tax return on assets declines by a little more than 0.6 percentage points. These two findings strongly suggest that the increase in the loan loss provisions/loans is the driver behind the decline in the return on assets of commercial banks, given that loans account for around 66 percent of commercial banks' total financial assets in 1986.<sup>31</sup>

The remarkable decline in the *after*-tax return on assets also makes clear that loan loss provisions do not only decline because banks use their discretionary power in adjusting their loan loss provisions in order to smooth out the increase in corporate income taxes stemming from the 1986 TRA.<sup>32</sup> We therefore conclude that the increase in the loan loss provisions/loan ratio must mainly be driven by a deterioration in the quality of the loan portfolio.

We therefore investigate in which loan group banks experience an increase in non-performing loans. To do so, we use quarterly data from the Federal Deposit Insurance Corporation's Quarterly Banking Profile Database.<sup>33</sup> We focus on two major subgroups, real estate loans and commercial and industrial (C&I) loans. For these two subgroups, there are also sufficiently long time series available for non-performing loans, starting from 1984Q1. Non-performing loans are defined as loans that are more than 90 days past due or in non-accrual status. We normalize the number of non-performing loans by the number of total loans in the respective category, and include the resulting ratio as an endogenous variable into Specification 5.

As Figure 16 makes evident, following an increase in corporate income taxes, only the fraction of non-performing C&I loans increases significantly. It is interesting to observe that the shape of the impulse response of non-performing C&I loans coincides almost perfectly with the reaction of the loan loss provisions/loan ratio.

Hence, we conclude that an increase in corporate income tax changes appears to affect banks' balance sheet conditions through an increase in the fraction of non-performing C&I loans. In the next subsection, we will investigate why this is the case.

**The impact of corporate income tax changes on banks' balance sheet conditions: a detailed analysis focusing on specific tax acts.** We now want to shed further light on why corporate income tax adjustments affect the fraction of non-performing C&I loans. As our previous analysis suggested, the increase in non-performing loans following an increase in corporate income taxes

<sup>30</sup>Access to the Bank Regulatory Database was obtained through Wharton Research Data Services.

<sup>31</sup>See Table L.111 in the US Financial Accounts for U.S.-Chartered Depository Institutions, Excluding Credit Unions.

<sup>32</sup>See Balla, Rose, and Romero (2012) on the use of loan loss provisions as a device to smooth taxes. Kuprianov (1997) describes the changes that were introduced by the 1986 TRA regarding the deductibility of loan loss provisions from banks' income statement.

<sup>33</sup><https://www2.fdic.gov/qbp/index.asp>, retrieved May 26, 2015.

leads to higher loan loss provisions, relative to total loans. Consequently, banks' balance sheet conditions deteriorate, as indicated by the decline in the return on assets of banks.

There are four tax events that affected corporate income taxes in the period for which data on non-performing C&I loans are available, namely the TRA of 1986, the OBRA of 1987, the OBRA of 1990, and finally the JGTRRA of 2003.

To analyze which of the four tax acts accounts for the change in the fraction of non-performing C&I loans, we modify Specification 5 by incorporating  $\Delta \text{tax}^{k,CI} \forall k \in \{1986, 1987, 1990, 2003\}$ , where  $k$  indicates one of the four tax events.  $\Delta \text{tax}^{k,CI}$  measures the change in corporate income tax liabilities/corporate income tax base for one of the four tax acts. The new system then looks as follows:

$$y_t = \sum_{i=1}^p A_i y_{t-i} + \sum_{j=0}^s B_j^{k,CI} \Delta \text{tax}_{t-j}^{k,CI} + D + Et + u_t \quad \forall k \in \{1986, 1987, 1990, 2003\}. \quad (6)$$

The vector of endogenous variables  $y$  consists of our baseline variables (including APITR and ACITR) and the fraction of non-performing C&I loans. We set  $p = 3$  and  $s = 2$ . Our results are robust to different choices of  $s$  and  $p$  as long as  $s \geq 2$ . We are interested in the dynamic multiplier  $D^{k,CI}(L) := A(L)^{-1} B^{k,CI}(L) \forall k \in \{1986, 1987, 1990, 2003\}$ .  $D$  and  $E$  control for a constant and a time trend.

Note that the magnitude of the responses found by considering Specification 5, where we measure the impact of all corporate income tax changes, cannot be compared to the magnitude of the responses obtained from Specification 6, due to differences in scaling. In the following, we will therefore focus on whether the impulse responses are significant, and not on the size of the multiplier. Also note that in order to ensure consistency with our other results, when we plot the respective impulse responses, we consider the impulse response after a tax *increase*, even if a specific tax event entailed a decline in corporate income taxes.

In Figure 17, we present the response of the fraction of non-performing loans for each of the aforementioned tax acts. Interestingly, only the 1986 TRA appears to have a significant impact on non-performing loans. Moreover, the shape of the impulse response looks strikingly similar to the one that we obtained from considering all corporate income tax changes. In sum, this suggests that the effects of corporate income tax changes on the fraction of non-performing loans are entirely driven by the 1986 TRA.

If we analyze the response of the loan loss provisions/loan ratio using Specification 6, we also find that the 1986 TRA is responsible for the aggregate effect, see Figure 18.<sup>34</sup> Our results furthermore indicate that the 1986 TRA is the driving force behind the responses of the return on assets and of FBP to corporate income tax changes, as is depicted in Figures 19 and 20 respectively.

As Figure 20 indicates, the 1986 TRA is not the only tax act that affects FBP. The 1987 OBRA and the 1990 OBRA do so as well, albeit it is worth noting that the response of FBP to the 1987 OBRA is only marginally significant. Interestingly, the return on assets does not respond significantly to either the 1987 or the 1990 OBRA (recall Figure 19). This suggests that, in these cases, FBP must be determined by factors other than balance sheet conditions of the financial sector. Alternatively, there

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<sup>34</sup>Note that there is a negative reaction of the loan loss provisions/loan ratio after the 1987 OBRA. According to the theory outlined in Section 2.2, this would imply a decrease in FBP. As shown in Figure 20, the opposite is the case. Moreover, the 1987 OBRA does not have a significant impact on the return on assets of commercial banks, as depicted in Figure 19. Therefore, we conclude that the response after the 1987 OBRA is not driven by banks' balance sheet conditions, and therefore, we do not analyze the 1987 OBRA in further detail.

could be other events that coincided with these two tax acts and that caused strains to the financial system, which then show up as an increase in FBP. The 1990 OBRA, for example, was implemented during the recession of 1990-1, which was likely exacerbated by capital pressures on commercial banks following the implementation of Basel I, see e.g. Bernanke and Lown (1991) and Gilchrist and Zakrajšek (2011).

In the following section, we will analyze how the 1986 TRA could have affected the fraction of non-performing C&I loans. We will also analyze potential factors that might confound the impact of the 1986 TRA.

**The importance of the 1986 TRA.** We now analyze in more detail how the 1986 TRA affects the fraction of non-performing C&I loans. Since we do not have information about the sectoral composition of non-performing C&I loans, we are forced to take an indirect approach.

We first construct a time series for the failure rates of firms for all sectors. This allows us to find out which industries experienced an increase in their firms' failure rates after the implementation of the 1986 TRA. In a second step, we then analyze whether the sectors that experienced an increase in their failure rates also depend on bank loans. In a third step, we link the increase in firms' failure rates in the aftermath of the 1986 TRA to the rise in the fraction of non-performing C&I loans.

We compute failure rates of firms using data on firm death from the Business Dynamics Survey (BDS).<sup>35</sup> According to the BDS definition, a firm died in a specific year if it exited in its entirety during this year. To be considered a firm death, all establishments owned by the firm must exit.<sup>36</sup> We calculate the failure rate in a specific sector by dividing the number of exiting firms in a given year by the total number of firms in that sector. Note that data are available on a yearly basis only. This prevents us from formally studying the response of the sector-specific failure rates to the 1986 TRA by incorporating the failure rate as an endogenous variable in our quarterly VAR.

Instead, we plot in Figure 21 the sector-specific failure rates for agriculture, construction, manufacturing, mining, retail trade, wholesale trade, services as well as finance, insurance, and real estate. For most sectors, failure rates are stable across years, with the exception of mining, which experienced a sharp increase in its failure rates in 1987, the year after the 1986 TRA was implemented.

This suggests that firm failures in the mining industry could be the reason for the increase in non-performing loans in the aftermath of the 1986 TRA.<sup>37</sup> Firms in the mining sector depend strongly on bank loans, a fact that can be seen from the high bank loan/asset ratio, which is equal to 12 percent

<sup>35</sup>[http://www.census.gov/ces/dataproducts/bds/data\\_firm.html](http://www.census.gov/ces/dataproducts/bds/data_firm.html), retrieved on May 26, 2015.

<sup>36</sup>BDS Codebook, page 5. Note that this definition is quite narrow. According to the codebook, "[...] a firm with 100 establishments would not qualify as a firm death if 99 exited while 1 continued under different ownership." (page 5).

<sup>37</sup>It is perhaps surprising that the construction sector does not appear to be important. As noted above, one of the main objectives of the 1986 TRA was to 'level the playing field', which also meant to abolish investment in tax shelters. As noted by Poterba (1992), rental housing was one of the most actively used tax shelters in the beginning of the 1980s. The 1986 TRA is therefore typically associated with the downturn in the real estate segment, in particular with the decline in the construction industry (see again Poterba 1992). Indeed, Figure 21 shows a minor increase in failure rates of firms in the construction sector, but only in 1988. Compared to the spike in the failure rates in the mining sector, this increase is negligible. This suggests that firm failures in the construction sector are not responsible for the rise in the fraction of non-performing loans in banks' balance sheets. Moreover, according to our impulse responses, the peak in the fraction of non-performing loans occurred three quarters after the implementation of the 1986 TRA in December 1986, which suggests that most of the action took place in 1987, the year after the implementation of the 1986 TRA.



according to the data from the 1987 Quarterly Financial Report (QFR).<sup>38</sup> The bank loan/asset ratio in the mining industry is high, even compared to other capital-intensive sectors covered by the 1987 QFR, such as manufacturing. For manufacturing, the bank loan/asset ratio is only 8 percent.

We now analyze whether the increase in the failure rates of firms in the mining sector can potentially account for the rise in the fraction of non-performing C&I loans that we documented earlier. Figure 21 suggests that the failure rates in the mining industry increased between 1986 and 1987 by almost 30 percent, from 13.5 percent to 17.5 percent. Using the 1987 QFR, we find that bank loans to firms in the mining sector account for 3.5 percent of all bank loans to the sectors covered by the QFR.

Under the assumption that an increase in the firms' failure rates by 30 percent directly translates into an increase in the fraction of non-performing C&I loans in the mining sector, this suggests that we should see a rise of approximately one percentage point in the fraction of non-performing loans in the year after the 1986 TRA. Interestingly, our results for all corporate income tax changes (where it makes sense to consider magnitudes since we scale appropriately) indicate that increasing ACITR by one percentage point leads to a rise in the fraction of non-performing loans by around 0.6 percentage points.

The fact that not all sectors are covered by the QFR understates the total volume of bank loans. In this context, it is important to note that probably some firms from other sectors also failed as a consequence of the 1986 TRA, without affecting the aggregate failure rates in their respective sector. Heavy industries, for example, are part of the manufacturing sector. The number of firms in heavy industries is small, relative to the overall number of firms in the manufacturing sector. So it is unlikely that an increase in the failure rates in heavy industries leads to a rise in the overall failure rates in the manufacturing sector.<sup>39</sup>

Moreover, it is very likely that heavy industries also suffered from the 1986 TRA. To 'level the playing field,' – one of the main objectives of the 1986 TRA, according to Poterba (1992), required a broadening of the tax base by reducing investment in tax shelters and by abolishing tax deductions. As a result, the 1986 TRA sharply increased the effective tax rates for many firms by reducing deductions for capital expenditures and by eliminating the investment tax credit. Losers of the reform were therefore firms in capital-intensive sectors, such as mining or heavy industries. According to the calculations presented in Cutler (1988), heavy industries and mining were the two sectors that were predicted to experience the largest loss in their net income following the 1986 TRA.

An increase in failure rates for heavy industries is also likely to affect the fraction of non-performing C&I loans, since, according to the 1987 QFR, bank loans to heavy industries account for 4.5 percent of total bank loans. We therefore conclude from the discussion in this subsection that the 1986 TRA adversely affected non-performing C&I loans by increasing the effective tax rates for firms in the mining sector and in heavy industries more generally. The rise in non-performing C&I loans, in turn, had a negative impact on banks' balance sheet conditions. As a result, the effective risk aversion of the financial sector increased, as indicated by the rise in FBP. In the following subsection, we discuss an alternative explanation for the high firm failure rates in the mining sector, namely the decline in the oil

<sup>38</sup><http://www.census.gov/econ/qfr/historic.html>, retrieved on May 26, 2015. We define bank loans as the sum of STBANK (short-term debt in form of bank loans) + INSTBANKS (long-term debt in form of bank loans, due in less than one year) + LTBNKDEBT (long-term debt in form of bank loans, due in more than one year).

<sup>39</sup>Unfortunately, the Business Dynamics Survey does not allow for a finer breakdown of the sector-specific failure rates.

price during the 1980s.

**Discussion: declining oil prices as a confounding factor.** Between 1982 and 1987, oil prices fell substantially. The drop was particularly drastic in the first half of 1986, when oil prices plummeted by almost 50 percent. In this section, we discuss to what extent the decline in oil prices can account for the increase in failure rates in the mining sector. We are motivated by the fact that this sector mainly consists of firms mining for crude oil, coal and natural gas (Kilian 2008).

To shed more light on this issue, we plot the number of employees in mining and in oil and gas extraction, a subsector of mining. As Figure 22 makes evident, employment in oil and gas extraction peaked in 1982, declined steadily afterwards, and experienced a sharp drop in 1986, thereby following the oil price closely. Figure 22 also shows that the number of jobs that disappeared in oil and gas extraction is small, relatively to the dramatic fall in the number of employees in the mining sector as a whole. Consequently, there must have been other subsectors of mining that experienced a more drastic employment reduction, compared to oil and gas extraction. Coal and metal mining are obvious candidates, since in these two sectors, 50 percent of all jobs were cut, as noted by Plunkert (1990). However, the reason for the employment loss in these sectors was structural change, and not declining energy prices. According to Plunkert (1990), mining firms increasingly made use of labor-saving machinery. Many small mines, which did not invest in such equipment, were forced to close.

It is likely that the 1986 TRA accelerated this structural change. By removing the 10 percent investment tax credit, which had been – prior to the 1986 TRA – available for purchases of machinery and equipment, and by extending the lifetime over which business structures could be written off for tax purposes, the 1986 TRA raised the effective tax rate on machinery and equipment (Auerbach 1987). As a consequence, investment projects required a higher return in order to break even. Therefore, investing in new, labor-saving equipment became profitable only for large mines.<sup>40</sup> We therefore conclude that the main driver behind the increase in firms’ failure rates in the mining sector was not the decline in the oil price, but the structural change in coal and metal mining. While the 1986 TRA may not have entirely caused the observed decline, it certainly acted as an amplification mechanism for the structural change.

## 6 Conclusion

In this paper, we empirically document that tax changes affect financial market conditions. Using the Romer and Romer (2010) narrative record of exogenous federal tax liability changes for the US, we show that an increase in taxes leads to higher risk premia for corporate bonds issued by financial and non-financial firms. Using additional information by Mertens and Ravn (2013), which allows us

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<sup>40</sup>It should be noted that employment already deteriorates from the beginning of 1986 onwards, despite the fact that the 1986 TRA was officially implemented in 1986Q4. Kilian (2008) notes that “large parts of the Act were effective retroactively in the first quarter of 1986. Regardless of the exact timing of individual provisions, a good case can be made that firms anticipated that many provisions would be enacted retroactively and adjusted their investment decisions accordingly.” (see his Footnote 15). Of course, this conflicts with our assumption that the 1986 TRA was unanticipated. Our results remain valid as long as the full negative consequences of the 1986 TRA for banks and therefore EBP were not anticipated before its implementation. This seems plausible, given that failures rate do not increase before 1987, see Figure 21.

to distinguish between personal and corporate income taxation, we find that risk premia are driven by financial intermediaries' balance sheet conditions, a result that is consistent with recent theories of intermediary asset pricing, such as He and Krishnamurthy (2013) and Brunnermeier and Sannikov (2014). Moreover, we also analyze in detail how intermediaries' balance sheet conditions respond to tax changes.

Two tax acts turn out to be particularly important, namely the Tax Reform Act (TRA) of 1986 and the Jobs and Growth Tax Relief Reconciliation Act (JGTRRA) of 2003. Interestingly, none of these two tax acts specifically targeted the financial sector. Therefore, a general conclusion that emerges from our analysis is that any tax change can potentially spill over to financial market conditions, with the associated consequences for the real economy.

A promising avenue for future research could therefore be to analyze the effect of tax changes on real economic activity in a macro model with financial frictions, for example by using a model that features a financial accelerator, such as Bernanke and Gertler (1995), Kiyotaki and Moore (1997), and Bernanke, Gertler, and Gilchrist (1999). Alternative approaches to introduce financial frictions are models in which in which frictions affect financial intermediaries, such as e.g. Gertler and Kiyotaki (2010), Gertler and Karadi (2011), and Gertler, Kiyotaki, and Queralto (2012). These theories are perhaps closer in spirit to the results of our paper, as they feature financial intermediaries. It should be noted that only those theories can be suitable candidates for which a tax increase leads to a tightening of financial frictions.<sup>41</sup>

On the empirical side, further research should shed more light on the channels through which taxes affect intermediaries' balance sheet conditions. For example, more detailed information regarding the sectoral composition of commercial banks' C&I loans could be gathered in order to test whether the increase in the fraction of non-performing loans after the 1986 TRA is indeed connected to the increase in the failure rate of firms in the mining sector.

Another interesting avenue for further research would be to analyze alternative channels through which taxes could affect excess bond premia. Such an alternative channel could for example be changes in the supply of government bonds (see Krishnamurthy and Vissing-Jorgensen 2012). Further research could also clarify whether this channel can explain the increase in FBP following the 1990 Omnibus Budget Reconciliation Act (OBRA), which is shown in Figure 20.

These directions for future research can establish a more detailed understanding of the different channels that are at play in the transmission of tax changes to financial market conditions. In this paper, we have made an important first step by explaining how both corporate and personal income tax changes can ultimately affect funding conditions in the corporate bond market through altering balance sheet conditions of financial intermediaries.

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<sup>41</sup>This is not always the case. For example, in Fernández-Villaverde (2010), an increase in taxes implies higher inflation, which, in turn, raises entrepreneurs' net worth (in nominal terms), thereby reducing the external finance premium. Strulik (2008) studies the consequences of various forms of capital tax changes in a financial accelerator model à la Bernanke, Gertler, and Gilchrist (1999). He finds that an increase in the private capital income tax reduces the tax advantage of debt finance as opposed to equity, which, in turn, decreases leverage and therefore also the external finance premium. The opposite is the case after an increase in corporate income taxation.

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## Appendix

### A Data

The data used in our estimation are based on Romer and Romer (2009, 2010) and on the Online Appendix of Mertens and Ravn (2013). There are a few differences between our dataset and the one used by Romer and Romer (2009, 2010):

- We use a different timing convention than Romer and Romer (2009, 2010) and date every tax change in the quarter in which it was actually implemented. Romer and Romer (2009, 2010), on the other hand, only assign tax changes in the first half of the quarter to this same quarter, whereas tax changes that occurred after the midpoint of the quarter are assigned to the next quarter.
- We distinguish between anticipated and unanticipated tax changes. Specifically, we have three measures for unanticipated tax changes, depending on the lag between the announcement and implementation date: same month (called S1 in Table 1), 30 days (called S1-exceptions in Table 1) and 90 days (called S3 in Table 1). The measures we use – if not stated otherwise – are the S1-exceptions tax changes.
- We add the distinction between personal, corporate, and other tax changes, using data from the Online Appendix by Mertens and Ravn (2013). The exact decomposition between the different categories is shown in the last three columns of Table 2. In three cases, the personal, corporate, and other tax changes do not sum up to the total amount reported by Romer and Romer (2009, 2010). This is due to adjustments made by Mertens and Ravn (2013) and is marked with an asterisk in Table 2. Note that the decomposition into personal, corporate, and other tax changes is only available for those tax events with an implementation lag of less than one quarter.



Table 1: Timing of exogenous tax changes

Tax Act	Signed	Effective	S1	S1 + exceptions	S3	Our Timing	R&R Timing
1 Social Security Amendments of 1947	06/08/1947	01/1950	NO	NO	NO	1950Q1	1950Q1
2 Revenue Act of 1948	02/04/1948	04/1948	YES	YES	YES	1948Q2	1948Q2
3 Social Security Amendments of 1950	28/08/1950	01/1954	NO	NO	NO	1954Q1	1954Q1
4 Expiration of Excess Profits Tax and Temporary Income Tax Increases	10/1951	01/1954	NO	NO	NO	1954Q1	1954Q1
5 Internal Revenue Code of 1954	16/08/1954	08/1954	YES	YES	YES	1954Q3	1954Q4
6 Tax Rate Extension Act of 1958	30/06/1958	07/1958	NO	YES	YES	1958Q3	1958Q3
7 Social Security Amendments of 1958	28/08/1958	01/1960	NO	NO	NO	1960Q1	1960Q1
8 Federal-Aid Highway Act of 1959	21/09/1959	10/1959	NO	YES	YES	1959Q4	1959Q4
9 Social Security Amendments of 1958	30/06/1961	01/1963	NO	NO	NO	1963Q1	1963Q1
10 Changes in Depreciation Guidelines and Revenue Act of 1962	11/07/1962	07/1962	YES	YES	YES	1962Q3	1962Q3
	16/10/1962	10/1962	YES	YES	YES	1962Q4	1962Q4
	16/10/1962	01/1963	NO	NO	NO	1963Q1	1963Q1
11 Revenue Act of 1964	26/02/1964	02/1964	YES	YES	YES	1964Q1	1964Q2
	26/02/1964	01/1965	NO	NO	NO	1965Q1	1965Q1
12 Excise Tax Reduction Act of 1965	21/06/1965	06/1965	YES	YES	YES	1965Q2	1965Q3
	21/06/1965	01/1966	NO	NO	NO	1966Q1	1966Q1
13 Tax Adjustment Act of 1966	15/03/1966	03/1966	YES	YES	YES	1966Q1	1966Q2
14 Public Law 90-26	13/06/1967	06/1967	YES	YES	YES	1967Q2	1967Q3
15 Social Security Amendments of 1967	02/01/1968	01/1971	NO	NO	NO	1971Q1	1971Q1
16 Tax Reform Act of 1969	30/12/1969	01/1971	NO	NO	NO	1971Q1	1971Q1
	30/12/1969	01/1972	NO	NO	NO	1972Q1	1972Q1
17 Reform of Depreciation Rules	11/01/1971	01/1971	YES	YES	YES	1971Q1	1971Q1
18 Revenue Act of 1971	10/12/1971	01/1972	NO	YES	YES	1972Q1	1972Q1
19 1972 Changes to Social Security	30/10/1972	01/1978	NO	NO	NO	1978Q1	1978Q1
20 Tax Reform Act of 1976	04/10/1976	10/1976	YES	YES	YES	1976Q4	1976Q4
	04/10/1976	01/1977	NO	NO	NO	1977Q1	1977Q1
21 Tax Reduction and Simplification Act of 1977	23/05/1977	05/1977	YES	YES	YES	1977Q2	1977Q3
22 Social Security Amendments of 1977	20/12/1977	01/1979	NO	NO	NO	1979Q1	1979Q1
	20/12/1977	01/1980	NO	NO	NO	1980Q1	1980Q1
	20/12/1977	01/1981	NO	NO	NO	1981Q1	1981Q1
	20/12/1977	01/1982	NO	NO	NO	1982Q1	1982Q1
23 Revenue Act of 1978	06/11/1978	01/1979	NO	NO	YES	1979Q1	1979Q1
24 Crude Oil Windfall Profit Tax Act of 1980	02/04/1980	04/1980	YES	YES	YES	1980Q2	1980Q2
	02/04/1980	01/1981	NO	NO	NO	1981Q1	1981Q1
	02/04/1980	01/1982	NO	NO	NO	1982Q1	1982Q1
25 Economic Recovery Tax Act of 1981	13/08/1981	08/1981	YES	YES	YES	1981Q3	1981Q3
	13/08/1981	01/1982	NO	NO	NO	1982Q1	1982Q1
	13/08/1981	01/1983	NO	NO	NO	1983Q1	1983Q1
	13/08/1981	01/1984	NO	NO	NO	1984Q1	1984Q1
26 Tax Equity and Fiscal Responsibility Act of 1982	03/09/1982	01/1983	NO	NO	NO	1983Q1	1983Q1
27 Social Security Amendments of 1983	20/04/1983	01/1984	NO	NO	NO	1984Q1	1984Q1
	20/04/1983	01/1985	NO	NO	NO	1985Q1	1985Q1
	20/04/1983	01/1986	NO	NO	NO	1986Q1	1986Q1
	20/04/1983	01/1988	NO	NO	NO	1988Q1	1988Q1
	20/04/1983	01/1990	NO	NO	NO	1990Q1	1990Q1
28 Deficit Reduction Act of 1984	18/07/1984	07/1984	YES	YES	YES	1984Q3	1984Q3
29 Tax Reform Act of 1986	22/10/1986	10/1986	YES	YES	YES	1986Q4	1986Q4
	22/10/1986	01/1987	NO	NO	NO	1987Q1	1987Q1
	22/10/1986	07/1987	NO	NO	NO	1987Q3	1987Q3
	22/10/1986	01/1988	NO	NO	NO	1988Q1	1988Q1
30 Omnibus Budget Reconciliation Act of 1987	22/12/1987	01/1988	NO	YES	YES	1988Q1	1988Q1
31 Omnibus Budget Reconciliation Act of 1990	05/11/1990	01/1991	NO	NO	YES	1991Q1	1991Q1
32 Omnibus Budget Reconciliation Act of 1993	10/08/1993	08/1993	YES	YES	YES	1993Q3	1993Q3
	10/08/1993	10/1993	NO	NO	YES	1993Q4	1993Q4
	10/08/1993	01/1994	NO	NO	NO	1994Q1	1994Q1
33 Taxpayer Relief Act of 1997 and Balanced Budget Act of 1997	05/08/1997	01/2000	NO	NO	NO	2000Q1	2000Q1
	05/08/1997	01/2002	NO	NO	NO	2002Q1	2002Q1
34 Economic Growth and Tax Relief Reconciliation Act of 2001	07/06/2001	01/2002	NO	NO	NO	2002Q1	2002Q1
35 Jobs and Growth Tax Relief Reconciliation Act of 2003	28/05/2003	05/2003	YES	YES	YES	2003Q2	2003Q3
	28/05/2003	01/2005	NO	NO	NO	2005Q1	2005Q1

Table 2: Size and category of exogenous tax changes

Tax Act	Our Timing	Total Amount (in billion)	Deficit-Driven	Long-Run	Personal	Corporate	Other
1 Social Security Amendments of 1947	1950Q1	0.75	0.75				
2 Revenue Act of 1948	1948Q2	-5.00		-5.00	-5.00		
3 Social Security Amendments of 1950	1954Q1	1.30	1.30				
4 Expiration of Excess Profits Tax and Temporary Income Tax Increases	1954Q1	-1.30	-1.30				
5 Internal Revenue Code of 1954	1954Q3	-1.40		-1.40	-0.80	-0.60	
6 Tax Rate Extension Act of 1958	1958Q3	-0.50		-0.50			-0.50
7 Social Security Amendments of 1958	1960Q1	1.90	1.90				
8 Federal-Aid Highway Act of 1959	1959Q4	0.60	0.60				0.60
9 Social Security Amendments of 1958	1963Q1	2.00	2.00				
10 Changes in Depreciation Guidelines and Revenue Act of 1962	1962Q3	-1.35		-1.35		-1.35	
	1962Q4	-0.90		-0.90		-0.90	
	1963Q1	0.60		0.60			0.60
11 Revenue Act of 1964	1964Q1	-8.40		-8.40	-6.70	-1.70	
	1965Q1	-4.50		-4.50			
12 Excise Tax Reduction Act of 1965	1965Q2	-1.75		-1.75			-1.75
	1966Q1	-1.75		-1.75			
13 Tax Adjustment Act of 1966	1966Q1	0.90		0.90			0.90
14 Public Law 90-26	1967Q2	-1.60		-1.60		-1.60	
15 Social Security Amendments of 1967	1971Q1	3.60	3.60				
16 Tax Reform Act of 1969	1971Q1	-1.00		-1.00			
	1972Q1	-1.00		-1.00			
17 Reform of Depreciation Rules	1971Q1	-2.80		-2.80		-2.80	
18 Revenue Act of 1971	1972Q1	-8.00		-8.00	-3.80	-1.60	-2.60
19 1972 Changes to Social Security	1978Q1	2.90	2.90				
20 Tax Reform Act of 1976	1976Q4	2.40		2.40	1.65	0.75	
	1977Q1	-0.80		-0.80			
21 Tax Reduction and Simplification Act of 1977	1977Q2	-7.00		-7.00	-5.40	-1.60	
22 Social Security Amendments of 1977	1979Q1	8.80	8.80				
	1980Q1	1.70	1.70				
	1981Q1	17.20	17.20				
	1982Q1	1.50	1.50				
23 Revenue Act of 1978	1979Q1	-18.90		-18.90	-14.80	-6.50	
24 Crude Oil Windfall Profit Tax Act of 1980	1980Q2	8.20		8.20			8.20
	1981Q1	4.10		4.10			
	1982Q1	4.10		4.10			
25 Economic Recovery Tax Act of 1981	1981Q3	-8.90		-8.90			
	1982Q1	-48.80		-48.80			
	1983Q1	-57.30		-57.30			
	1984Q1	-36.10		-36.10			
26 Tax Equity and Fiscal Responsibility Act of 1982	1983Q1	26.40	26.40				
27 Social Security Amendments of 1983	1984Q1	12.10	12.10				
	1985Q1	8.80	8.80				
	1986Q1	4.20	4.20				
	1988Q1	15.50	15.50				
	1990Q1	10.30	10.30				
28 Deficit Reduction Act of 1984	1984Q3	8.00	8.00		5.6*	3.3*	0.4*
29 Tax Reform Act of 1986	1986Q4	22.70		22.70		22.70	
	1987Q1	-7.20		-7.20	-7.20		
	1987Q3	-20.00		-20.00			
	1988Q1	-7.20		-7.20			
30 Omnibus Budget Reconciliation Act of 1987	1988Q1	10.80	10.80		0.80	7.50	2.50
31 Omnibus Budget Reconciliation Act of 1990	1991Q1	35.20	35.20		14.00*	1.00*	18.00*
32 Omnibus Budget Reconciliation Act of 1993	1993Q3	22.80	22.80		22.80		
	1993Q4	5.30	5.30				5.30
	1994Q1	13.40	13.40				
33 Taxpayer Relief Act of 1997 and Balanced Budget Act of 1997	2000Q1	1.70	1.70				
	2002Q1	0.60	0.60				
34 Economic Growth and Tax Relief Reconciliation Act of 2001	2002Q1	-83.00		-83.00			
35 Jobs and Growth Tax Relief Reconciliation Act of 2003	2003Q2	-126.40		-126.40	-94.6*	-31.2*	
	2005Q1	68.10		68.10			

Notes: \*=deviations from the total amount by Romer and Romer (2009) are due to corrections made by Mertens and Ravn (2013)

Table 3: Sources and descriptions of variables

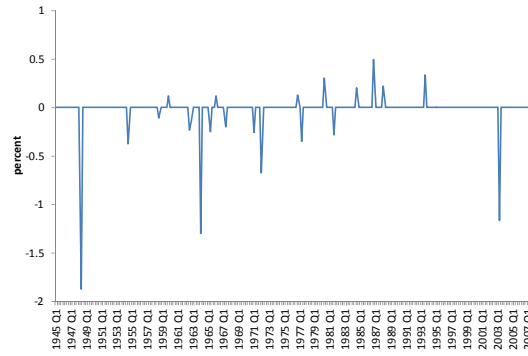
Variable	Description	Source
GDP	Nominal GDP, seasonally adjusted, in billions of USD; divided by the GDP deflator (2005=100) and by population.	FRED, St. Louis Fed
Durables Consumption	Nominal personal consumption expenditures on durable goods, seasonally adjusted, in billions of USD; divided by the durables expenditures deflator (2005=100) and by population.	FRED, St. Louis Fed
Non-Durables Consumption	Nominal personal consumption expenditures on non-durable goods, seasonally adjusted, in billions of USD; divided by the deflator for non-durable consumption (2005=100) and by population.	FRED, St. Louis Fed
Investment	Nominal gross private domestic investment, seasonally adjusted, in billions of USD; divided by the private investment deflator (2005=100) and by population.	FRED, St. Louis Fed
Hours	Product of hours worked and civilian non-farm employment; divided by population.	Dataset from Mertens and Ravn (2012)
Tax Revenues / GDP	Federal government current tax receipts, seasonally adjusted annual rate; divided by nominal GDP.	FRED, St. Louis Fed
Excess Bond Premium for Non-Financial Firms (EBP)	See description in Section 2.2 and Gilchrist and Zakrajšek (2012).	Dataset from Gilchrist and Zakrajšek (2012)
Excess Bond Premium for Financial Firms (FBP)	See description in Section 2.2 and Gilchrist and Zakrajšek (2011).	Dataset from Gilchrist and Zakrajšek (2011)
Aaa - Treasury spread	Moody's tries to include bonds with remaining maturities as close as possible to 30 years. Moody's drops bonds if the remaining life falls below 20 years, if the bond is susceptible to redemption, or if the rating changes. Since data on rates on 30-year Treasury Bonds are not available before 1977, we instead use the 20-year Treasury constant maturity rate, which is available from 1953 onwards, with the exception of the period between 1987 and 1992. For this period, we approximate the 20-year Treasury constant maturity rate by a linear combination of the 10-year and the 30-year Treasury constant maturity rate.	FRED, St. Louis Fed
Baa - Aaa spread	See above for Aaa-Treasury spread.	FRED, St. Louis Fed
Certificate of Deposits - Treasury Spread	3-Month Certificate of Deposit, secondary market rate - 3-Month Treasury bill, secondary market rate.	FRED, St. Louis Fed
Average Personal Income Tax Rate (APITR)	APITR is defined as the sum of personal current taxes and contributions to government social insurance; divided by personal taxable income.	FRED, St. Louis Fed

Table 3: Sources and descriptions of variables

Variable	Description	Source
Average Corporate Income Tax Rate (ACITR)	ACITR is defined as taxes on corporate profits; divided by corporate profits. Profits by Federal Reserve Banks are excluded.	FRED, St. Louis Fed
Pre-Tax Return on Assets of Commercial Banks	Pre-tax income (variable PIQ)/total assets (variable ATQ), annualized, in percent. Commercial Banks: all institutions with NAICS code 522.	Constructed from Compustat
After-Tax Return on Assets of Commercial Banks	Income before extraordinary items (variable IBQ)/total assets (variable ATQ), annualized, in percent. Commercial Banks: all institutions with NAICS code 522.	Constructed from Compustat
Return on Assets of the Aggregate Financial Sector	See Gilchrist and Zakrajšek (2012). Data are annualized, in percent.	Dataset from Gilchrist and Zakrajšek (2012)
Loan Loss Provisions / Loan Ratio	Ratio of loan loss provisions (variable riad4230) to total loans, net of unearned income (variable rcon2122), annualized, in percent.	Bank Regulatory Database
Fraction of Non-Performing C&I Loans	Non-performing loans are defined as loans that are more than 90 days past due or in non-accrual status, in percent of total outstanding C&I loans.	Federal Deposit Insurance Corporation's Quarterly Banking Profile Database
Fraction of Non-Performing Real Estate Loans	Non-performing loans are defined as loans that are more than 90 days past due or in non-accrual status, in percent of total outstanding real estate loans.	Federal Deposit Insurance Corporation's Quarterly Banking Profile Database
Excess Stock Market Return	Difference between the quarterly (value-weighted) stock market return (including dividends) of the New York Stock Exchange minus the return on short-run (3 months) T-Bills, annualized, in percent.	Constructed using data from the Center for Research in Security Prices (CRSP)
Price / Dividend Ratio	Stock market data used in "Irrational Exuberance," Princeton University Press, 2000, 2005, 2015, updated, see Shiller (2005).	<a href="http://www.econ.yale.edu/~shiller/data.htm">http://www.econ.yale.edu/~shiller/data.htm</a> , retrieved on May 19, 2015
Cyclically Adjusted Price / Earnings Ratio	Stock market data used in "Irrational Exuberance," Princeton University Press, 2000, 2005, 2015, updated, see Shiller (2005).	<a href="http://www.econ.yale.edu/~shiller/data.htm">http://www.econ.yale.edu/~shiller/data.htm</a> , retrieved on May 19, 2015

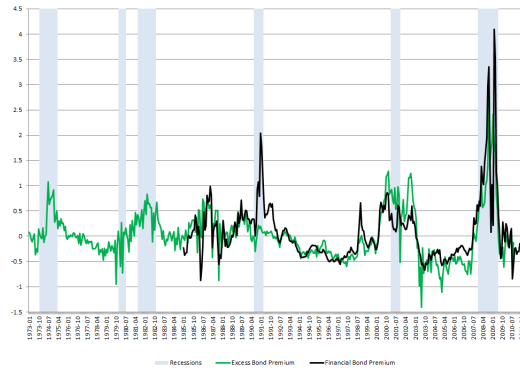
## B Figures

Figure 1: Unanticipated tax changes



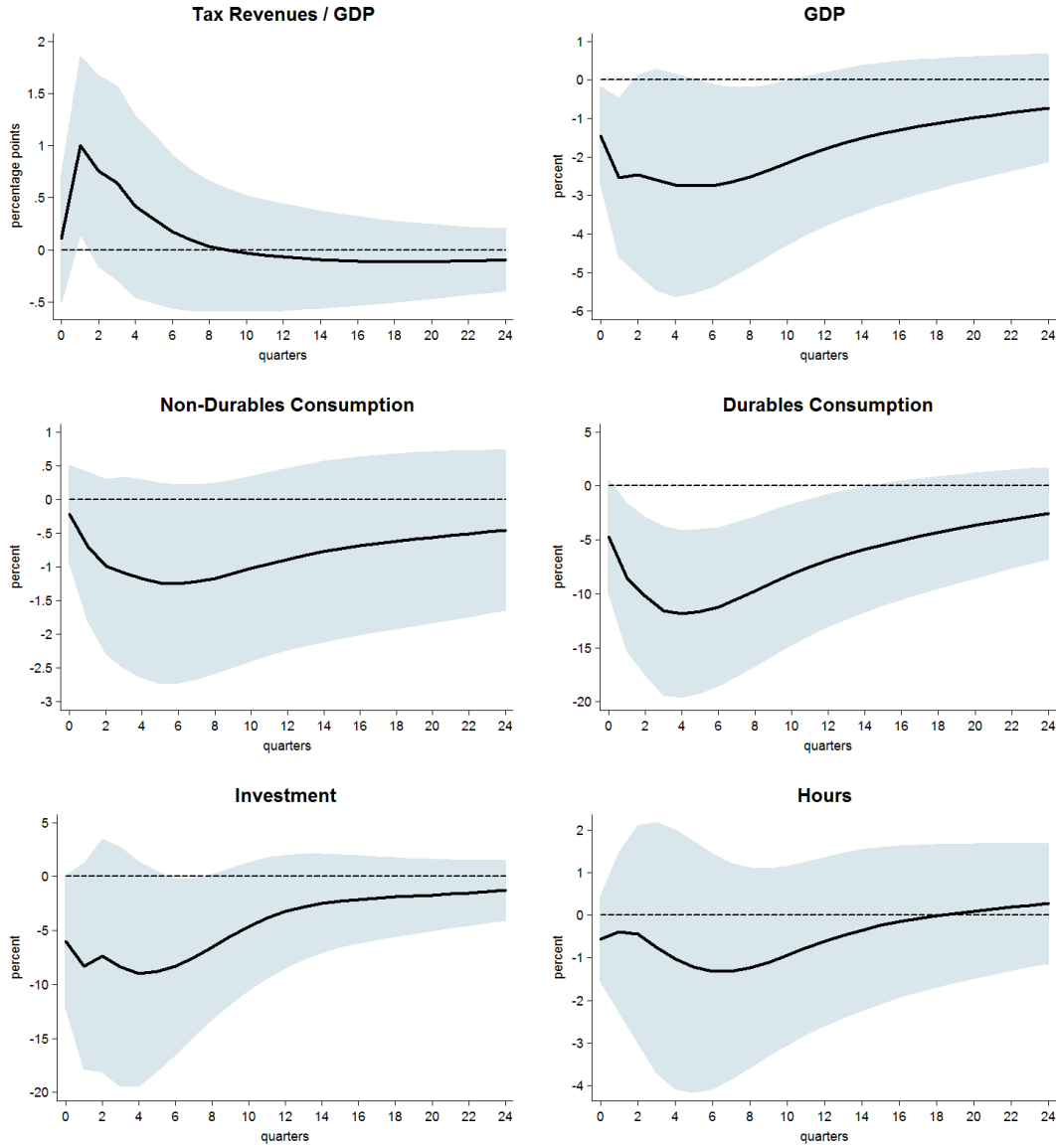
*Notes:* Unanticipated tax changes with a maximum implementation lag of 30 days. Tax changes are given in percent of GDP. Source: Own derivations based on Romer and Romer (2010), as described in Section 2.1 and in Appendix A, in particular Tables 1 and 2.

Figure 2: Excess bond premia



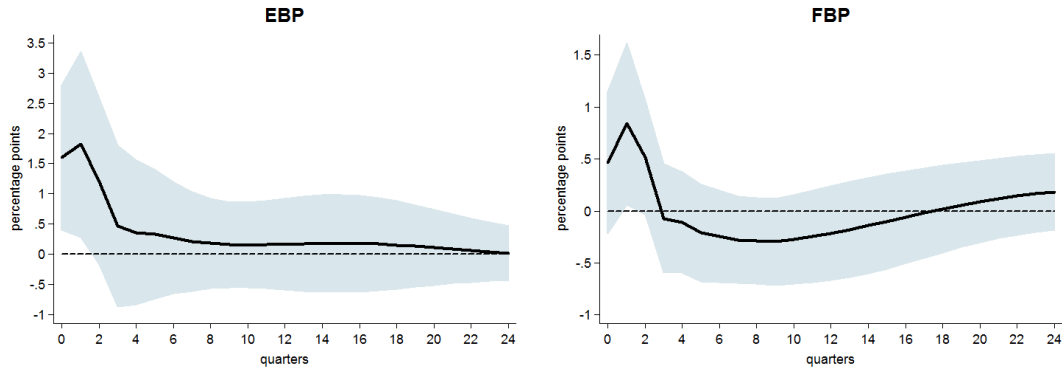
*Notes:* The excess bond premium for non-financial corporate firms (excess bond premium or EBP) and for financial corporate firms (financial bond premium or FBP), as constructed by Gilchrist and Zakrajšek (2011, 2012). The construction of EBP and FBP is described in Section 2.2. Shaded areas refer to NBER recessions.

Figure 3: Impulse responses of endogenous variables in baseline VAR



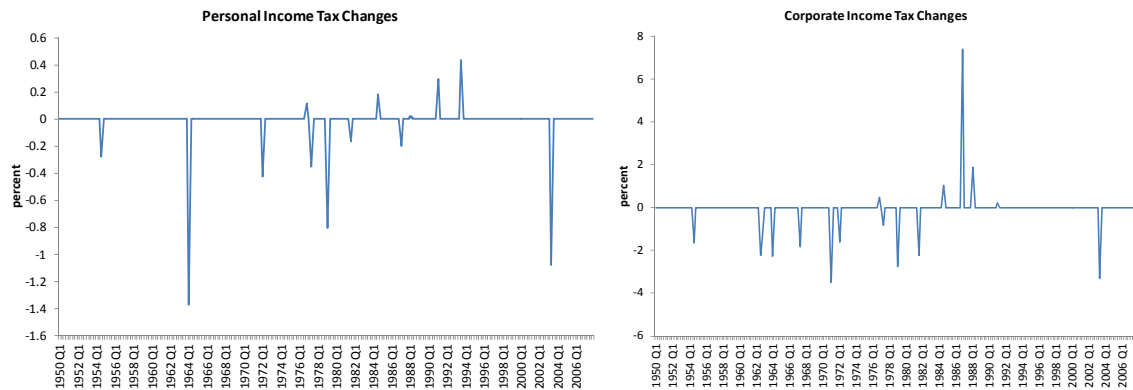
*Notes:* Impulse responses of endogenous variables in baseline VAR (see Specification 1 in Section 3), consisting of tax revenues/GDP, GDP, non-durables consumption, durables purchases, private investment, and hours worked to a one percentage point increase tax liabilities/GDP with 95 percent confidence intervals. For detailed variable definitions, please refer to Table 3. Narrative shocks are corrected for measurement error, as described in Appendix C.

Figure 4: Impulse responses of EBP and FBP



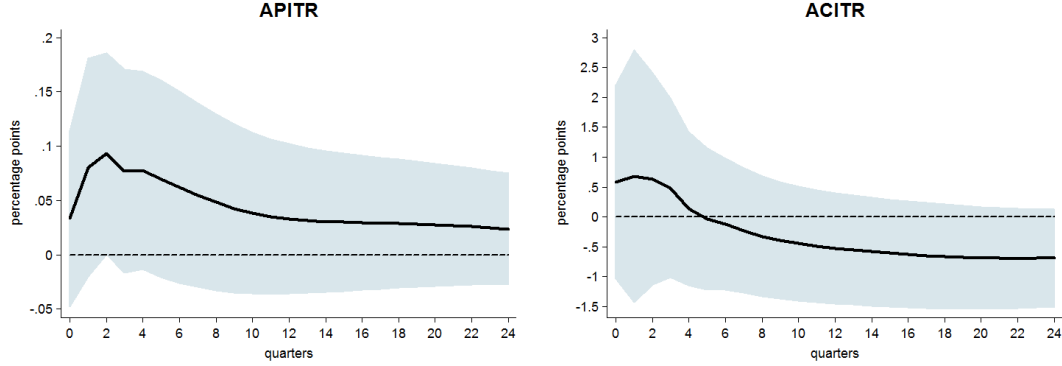
*Notes:* Impulse responses of either excess bond premia for non-financial (left panel) or financial (right panel) firms to a one percentage point increase tax liabilities/GDP with 95 percent confidence intervals, constructed by adding either EBP or FBP to Specification 1. Narrative shocks are corrected for measurement error, as described in Appendix C.

Figure 5: Personal and corporate income tax changes



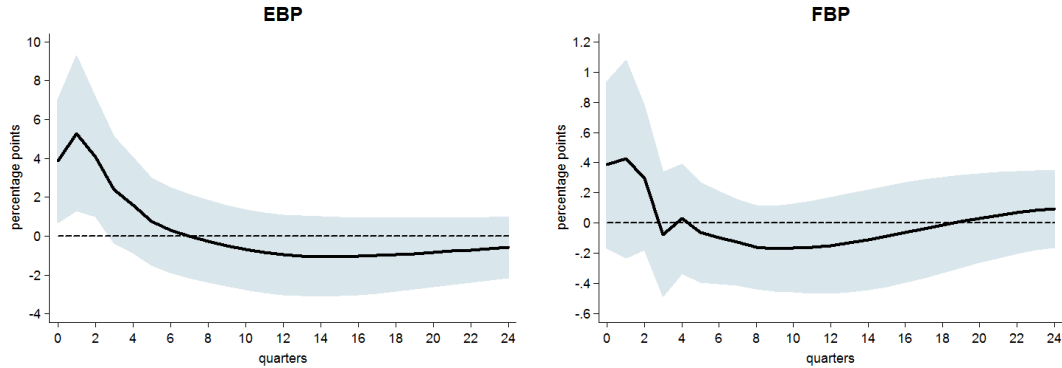
*Notes:* Personal income tax changes are given in percent of personal taxable income (left panel), and corporate income tax changes are given in percent of corporate profits (right panel). Source: Mertens and Ravn (2013). Detailed definitions are given in Appendix A, in particular Tables 1 and 2.

Figure 6: Impulse responses of APITR and ACITR



*Notes:* Cross-responses of the average personal income tax rate (APITR) and the average corporate income tax rate (ACITR) to a one percentage point increase in average corporate and personal income tax rate, respectively, using 95 percent confidence intervals. The underlying VAR is given by Specification 2, see Section 5. Narrative shocks are not corrected for measurement error, the size of the impulse responses should thus be interpreted as a lower bound.

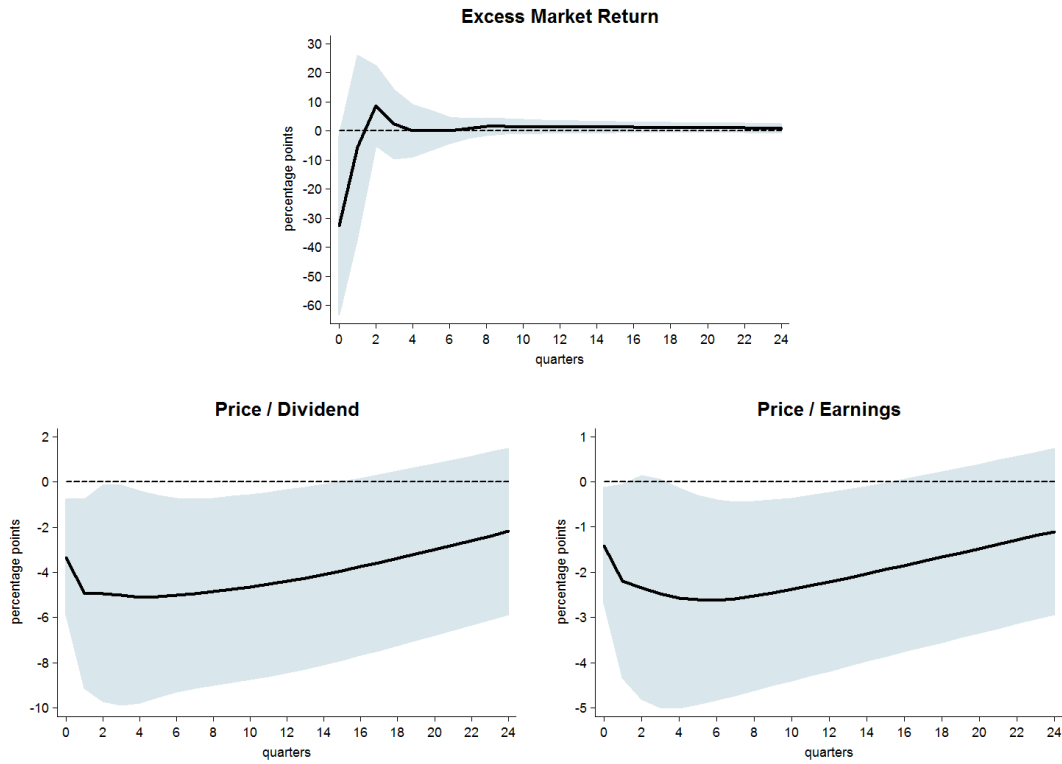
Figure 7: Impulse responses of EBP and FBP



*Notes:* Impulse responses of either excess bond premia for non-financial (left panel) or financial (right panel) firms to a one percentage point increase in the average personal income tax rate with 95 percent confidence intervals. The underlying VAR is given by Specification 3, see Section 5.1. Narrative shocks are corrected for measurement error, as described in Appendix C.

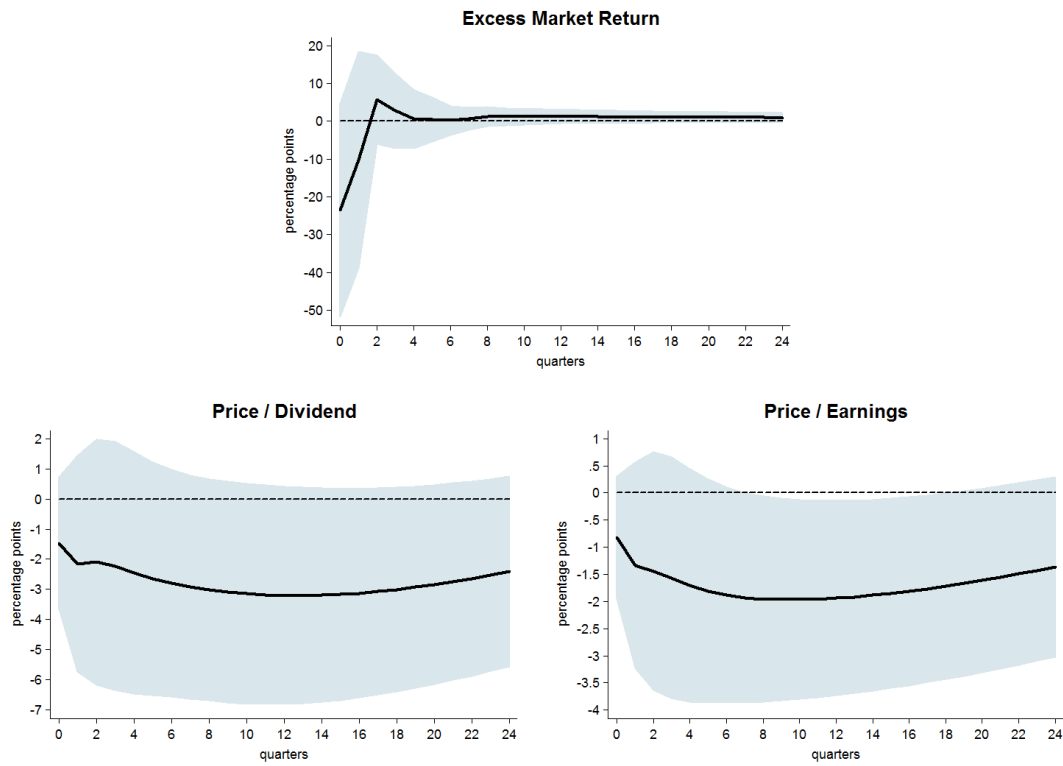


Figure 8: Impulse responses of stock market variables



*Notes:* Impulse responses of the excess market return, price/dividend ratio, and price/earnings ratio to a one percentage point increase in the average personal income tax rate with 90 percent (excess market return) and 95 percent confidence intervals (price/dividend ratio and price/earnings ratio). The underlying VAR is given by Specification 3, see Section 5.1. For detailed variable definitions, please refer to Table 3. Narrative shocks are corrected for measurement error, as described in Appendix C.

Figure 9: Impulse responses of stock market variables excluding the 2003 JGTRRA



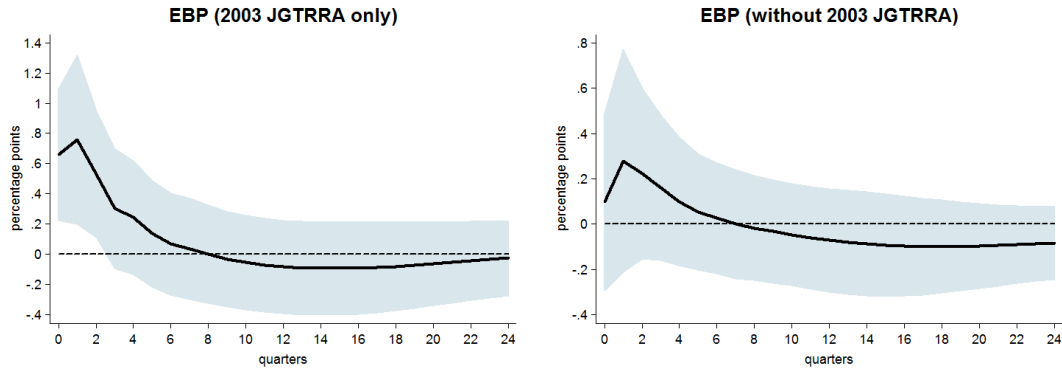
*Notes:* Impulse responses the excess market return, price/dividend ratio, and price/earnings ratio to a one percentage point increase in the average personal income tax rate excluding the 2003 JGTRRA. 90 percent (excess market return) and 95 percent confidence intervals (price/dividend ratio and price/earnings ratio). The underlying VAR is given by Specification 4, see Section 5.1. Narrative shocks are corrected for measurement error, as described in Appendix C.

Figure 10: Impulse responses of the return on assets of the financial sector



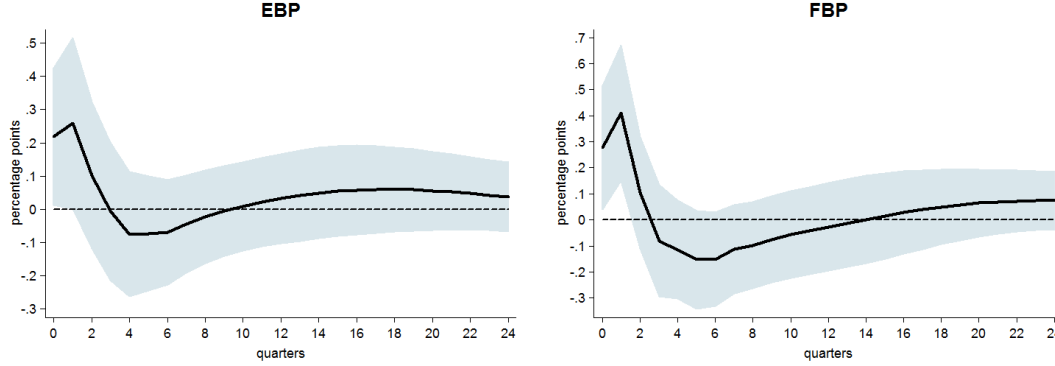
*Notes:* Impulse responses of the return on assets of the financial sector to the 2003 JGTRRA (left panel) and to a one percentage point increase in the average personal income tax rate excluding the 2003 JGTRRA (right panel) with 95 percent confidence intervals. The underlying VAR is given by Specification 4, see Section 5.1. Narrative shocks are corrected for measurement error, as described in Appendix C. For detailed variable definitions, please refer to Table 3.

Figure 11: Impulse responses of EBP



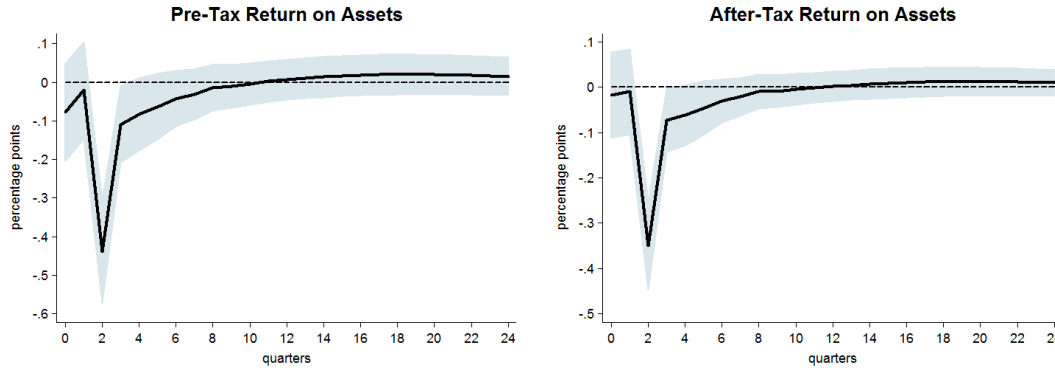
*Notes:* Impulse responses of the excess bond premium for non-financial firms to the 2003 JGTRRA (left panel) and to a one percentage point increase in the average personal income tax rate excluding the 2003 JGTRRA (right panel) with 95 percent confidence intervals. The underlying VAR is given by Specification 4, see Section 5.1. Narrative shocks are corrected for measurement error, as described in Appendix C.

Figure 12: Impulse responses of EBP and FBP



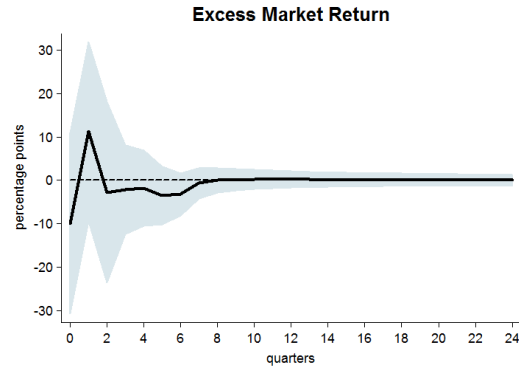
*Notes:* Impulse responses of excess bond premia for non-financial (left panel) and financial (right panel) firms to a one percentage increase in the average corporate income tax rate with 95 percent confidence intervals. The underlying VAR is given by Specification 5, see Section 5.2. Narrative shocks are corrected for measurement error, as described in Appendix C.

Figure 13: Impulse responses of the return on assets of commercial banks



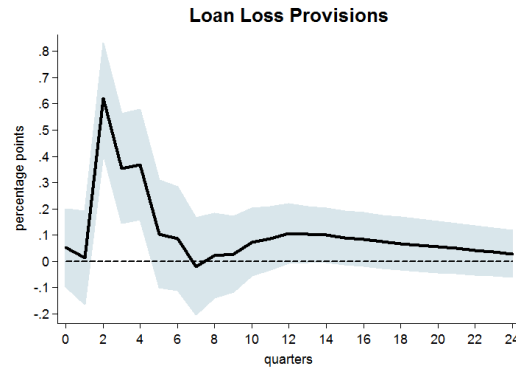
*Notes:* Impulse responses of the pre-tax return on assets of commercial banks (left panel) and the after-tax return on assets of commercial banks (right panel) to a one percentage point increase in the average corporate income tax rate with 95 percent confidence intervals. The underlying VAR is given by Specification 5, see Section 5.2. Narrative shocks are corrected for measurement error, as described in Appendix C.

Figure 14: Impulse response of the excess stock market return



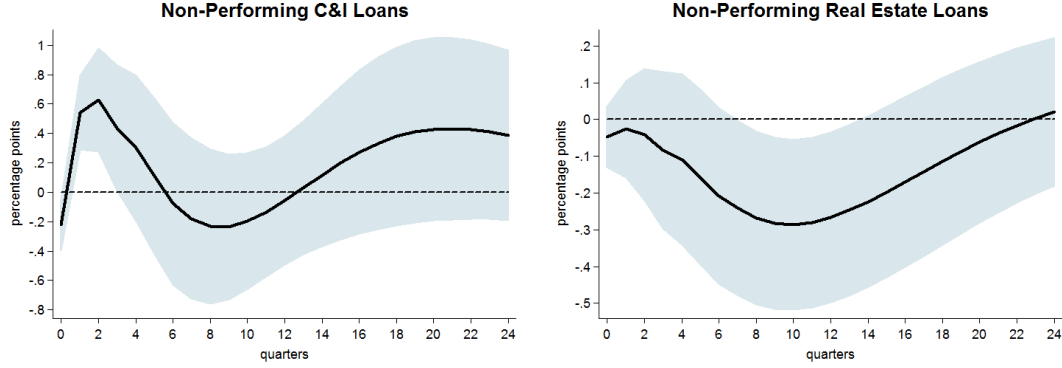
*Notes:* Impulse response of the excess stock market return to a one percentage point increase in the average corporate income tax rate with 95 percent confidence intervals. The underlying VAR is given by Specification 5, see Section 5.2. Narrative shocks are corrected for measurement error, as described in Appendix C.

Figure 15: Impulse response of loan loss provisions/loans



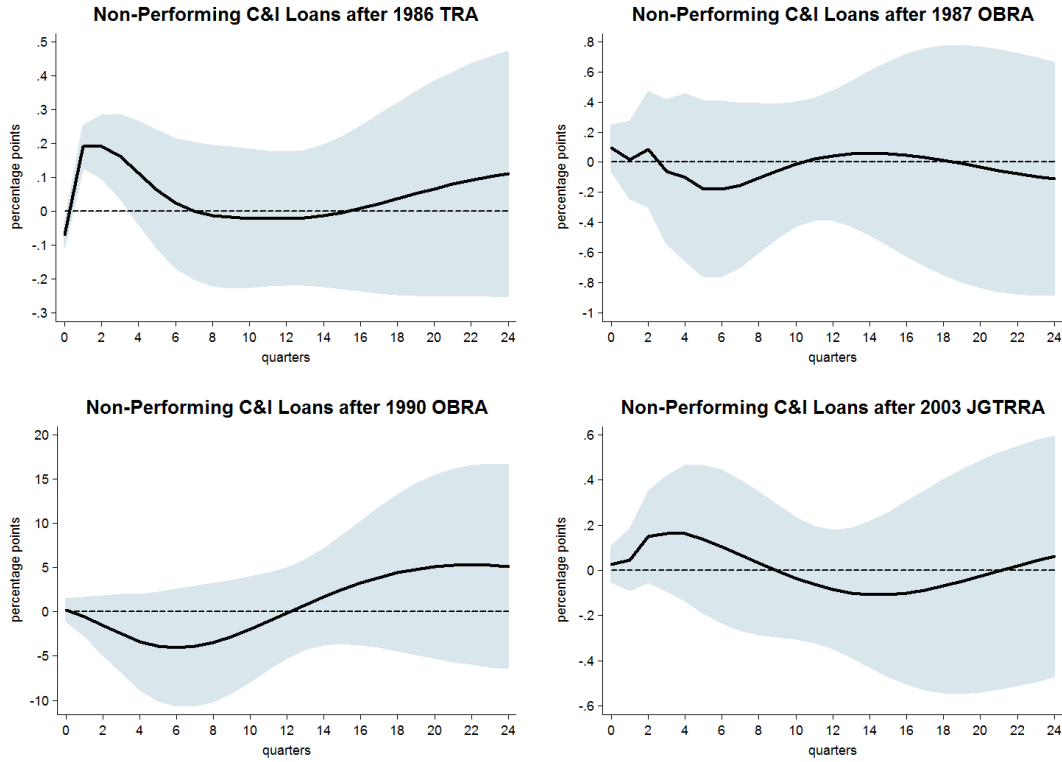
*Notes:* Impulse response loan loss provisions/loans to a one percentage point increase in the average corporate income tax rate with 95 percent confidence intervals. The underlying VAR is given by Specification 5, see Section 5.2. Narrative shocks are corrected for measurement error, as described in Appendix C.

Figure 16: Impulse responses of the share of non-performing loans



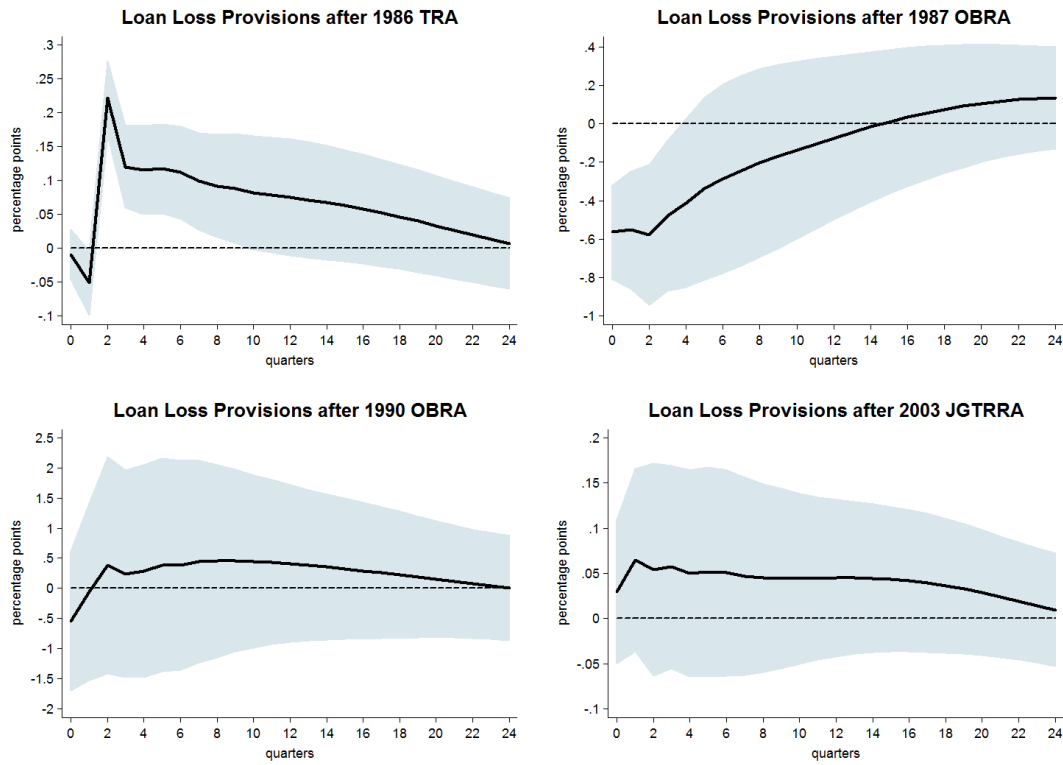
*Notes:* Impulse responses of the share of non-performing loans to a one percentage point increase in average corporate income tax rate with 95 percent confidence intervals. The underlying VAR is given by Specification 5, see Section 5.2. Narrative shocks are corrected for measurement error, as described in Appendix C.

Figure 17: Impulse responses of the share of non-performing C&I loans



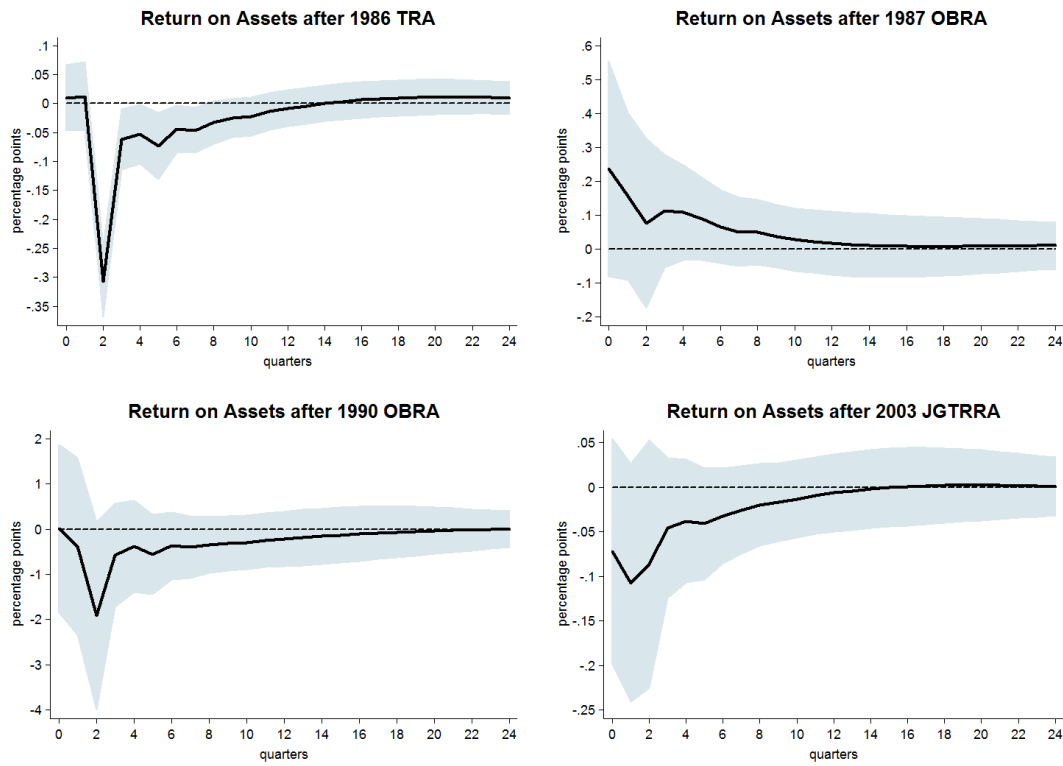
*Notes:* Impulse responses of the share of non-performing Commercial & Industrial loans to the corporate income tax component of specific tax acts with 95 percent confidence intervals. The underlying VAR is given by Specification 6, see Section 5.2. Narrative shocks are not corrected for measurement error, the size of the impulse responses should thus be interpreted as a lower bound.

Figure 18: Impulse responses of loan loss provisions/loans



*Notes:* Impulse responses of loan loss provisions/loans to the corporate income tax component of specific tax acts with 95 percent confidence intervals. The underlying VAR is given by Specification 6, see Section 5.2. Narrative shocks are not corrected for measurement error, the size of the impulse responses should thus be interpreted as a lower bound.

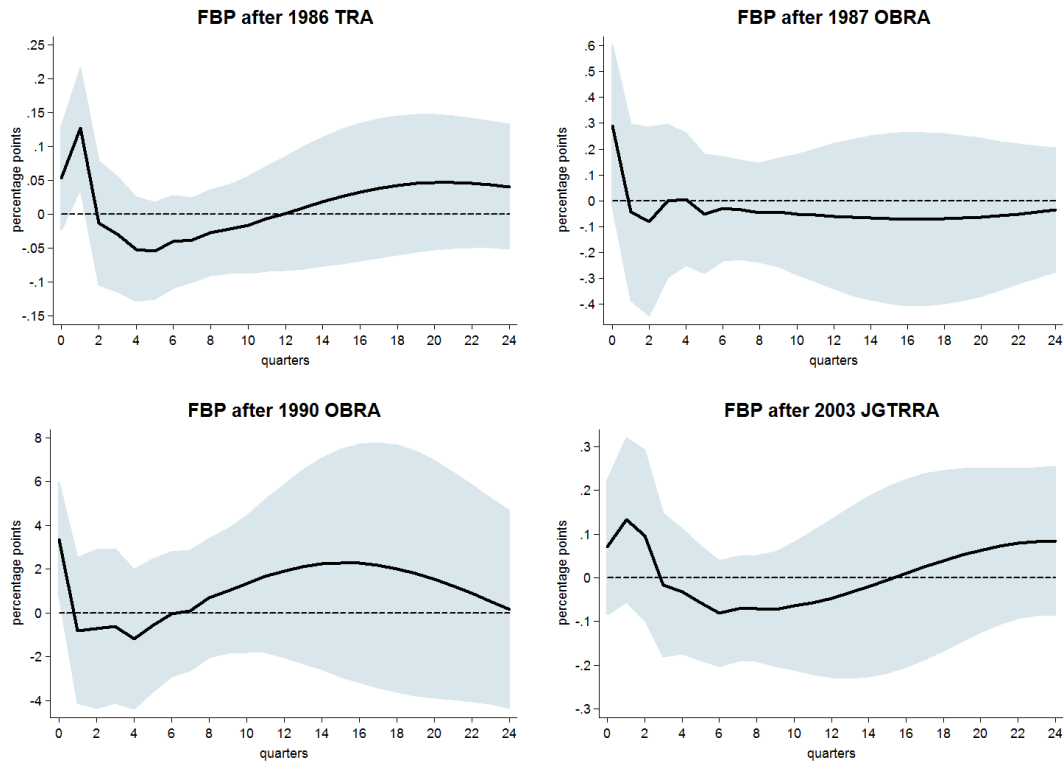
Figure 19: Impulse responses of the return on assets of commercial banks



*Notes:* Impulse responses of the return on assets of commercial banks to the corporate income tax component of specific tax acts with 95 percent confidence intervals. The underlying VAR is given by Specification 6, see Section 5.2. Narrative shocks are not corrected for measurement error, the size of the impulse responses should thus be interpreted as a lower bound.

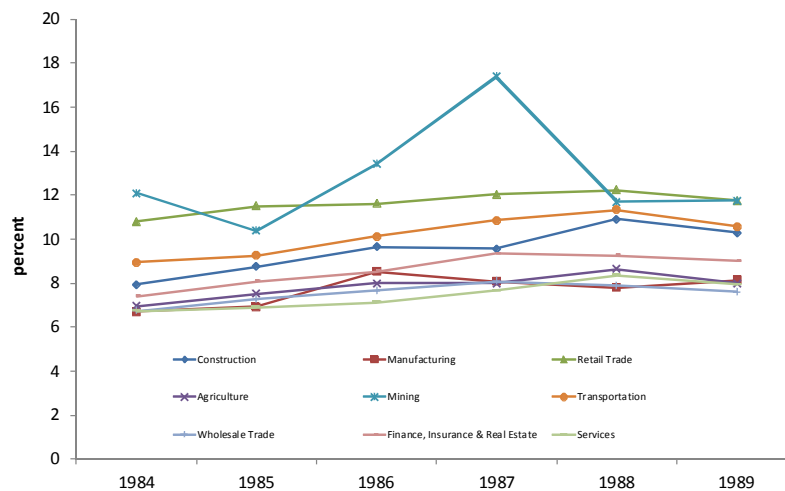


Figure 20: Impulse responses of FBP



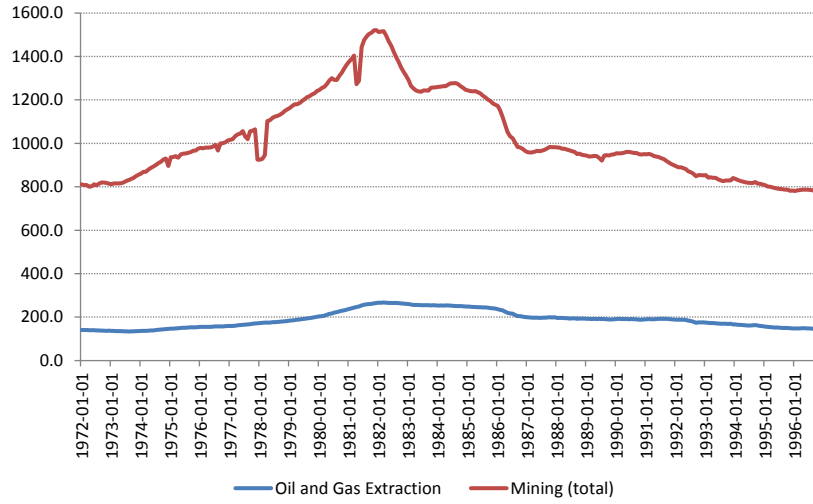
*Notes:* Impulse responses of the excess bond premium for financial firms to the corporate income tax component of specific tax acts with 95 percent confidence intervals. The underlying VAR is given by Specification 6, see Section 5.2. Narrative shocks are not corrected for measurement error, the size of the impulse responses should thus be interpreted as a lower bound.

Figure 21: Failure rates of firms



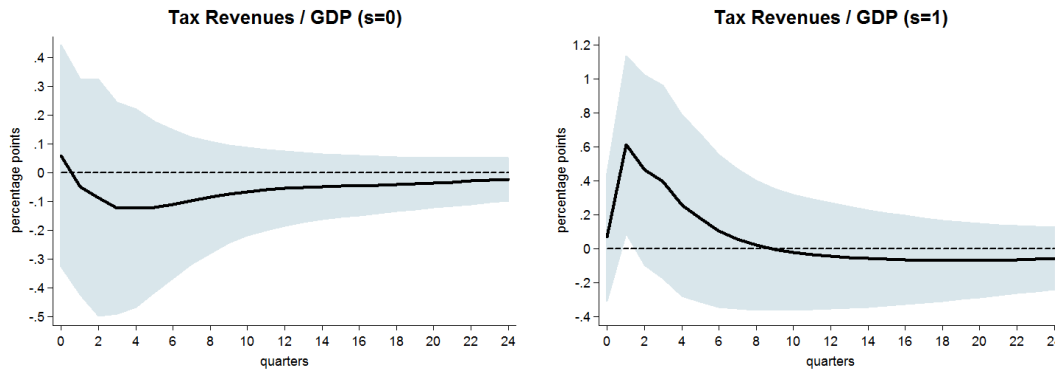
*Notes:* Failure rates of firms in different sectors. Source: Own calculations based on data from the Business Dynamics Survey.

Figure 22: Number of employees in mining and oil and gas extraction



Notes: Number of employees (in thousands) in mining and in oil and gas extraction, which is a subsector of mining.

Figure 23: Impulse responses of tax revenues/GDP



Notes: Impulse responses of tax revenues/GDP in baseline VAR (see Specification 1) to an uncorrected increase in tax liabilities using the Romer and Romer (2010) scaling with 95 percent confidence intervals. VAR using no lag (left panel) and one lag (right panel) for the exogenous variable, the narrative account of unanticipated taxes. See Appendix C for further details.

## C Details Econometric Model

**Determination of  $s$ .** The number of lags of the exogenous variable  $s$  determines the number of periods during which a narrative tax shock  $\Delta\text{tax}_t$  affects the system of endogenous variables. Ideally, we would like to estimate an infinitely distributed lag model to measure the impact of exogenous tax shocks, see e.g. Romer and Romer (2010) and Cloyne (2013). That is, we would like to set  $s$  to a very large number. However, there is a trade-off between a long lag structure and saving degrees of freedom, in particular in small samples. Following Romer and Romer (2010), many authors have set  $s = 12$ , see e.g. Mertens and Ravn (2011, 2012) and Cloyne (2013). In contrast to us, these authors do not incorporate the average tax rate (i.e. tax revenues/GDP) as an endogenous variable. This is done by Favero and Giavazzi (2012), who set  $s = 0$ , i.e. they only consider contemporaneous values of  $\Delta\text{tax}_t$ .

We depart from Favero and Giavazzi (2012) and set  $s = 1$ , for the following reason. The narrative record of  $\Delta\text{tax}_t$  measures changes in tax liabilities, whereas in the data, we observe changes in tax revenues. We would expect that, for administrative reasons, it takes time before a tax liability change shows up as a change in tax revenues. This time lag is captured by  $s$ , among other things.

In Figure 23, we compare the impulse responses of tax revenues/GDP for  $s = 0$  and  $s = 1$ . For  $s = 0$ , we observe only a small initial response of tax revenues/GDP to an exogenous increase in tax liabilities/GDP by one percentage point. If we set  $s = 1$ , the response becomes hump-shaped with a peak in the first quarter following the tax increase. Since the response at the peak is much larger than on impact, this suggests that there is a time lag of one quarter until the increase in tax liabilities translates into higher tax revenues. This is in line with Perotti (2012), who also argues that it takes time until tax revenues react after a tax change.

The shape of the impulse response of tax revenues/GDP remains constant for all  $s \geq 1$ . We therefore use  $s = 1$  in our estimation procedure. We would like to stress that all our results are also robust to a longer lag structure for  $\Delta\text{tax}_t$ .

**Correcting for measurement error.** In Figure 23 (left panel), we trace out the impact of an uncorrected tax shock, derived from the Romer and Romer (2010) narrative, on tax revenues/GDP. The tax shock does not change tax revenues/GDP one-to-one.<sup>42</sup> Our results might therefore be subject to an attenuation bias.<sup>43</sup>

Our procedure to correct for the resulting bias is inspired by Stock and Watson (2012) and by Mertens and Ravn (2013). More precisely, we normalize the narrative tax liability changes such that a one unit positive shock to tax liabilities increases tax revenues/GDP by one percentage point at the peak.<sup>44</sup> We therefore interpret the ‘corrected’ shock as raising tax liabilities/GDP by one percentage point. The impact of this corrected shock series on tax revenues/GDP is depicted in the first panel of Figure 3.

<sup>42</sup>This is partly due to the fact that a change in tax liabilities, expressed in percent of GDP (the normalization for tax shocks used by Romer and Romer 2010), is not equivalent to a change in tax liabilities/GDP, unless GDP is constant.

<sup>43</sup>Interestingly, Hebous and Zimmermann (2015) show that there is a close connection between what we call ‘measurement problems’ and the fact that narratives tend to be weak instruments, as outlined in Footnote 17.

<sup>44</sup>Stock and Watson (2012) and Mertens and Ravn (2013) normalize tax shocks according to the response of the endogenous variable on impact. Due to the difference between tax liabilities and tax revenues and the associated time lag discussed above, we argue that our normalization procedure leads to a better assessment of the bias. Normalizing according to the response of tax revenues/GDP on impact would result in even larger multipliers.