Taxes and
the Labor Market

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One of the defining features of the financial crisis of 2008–09 has been its persistent impact on the U.S. labor market, with the unemployment rate roughly doubling from early 2008 through mid-2010. This has ignited an intense debate on the appropriate stimulus response of fiscal policy. The debate has revolved around two main issues: the relative merits of higher government spending versus tax cuts; and the suitability of labor income versus capital income tax cuts. In Monacelli, Perotti, and Trigari (2010), we address part of the debate related to the first point, particularly in relation to estimating the size of the unemployment multiplier of government spending. In this paper, we focus on the effects of tax variations on the labor market.

The idea that tax cuts are likely to be a more effective stimulus device than higher government spending is widespread in both the business and the academic community. This idea, however, often remains vague, because proponents typically do not distinguish between the expansionary effects of tax cuts on gross domestic product (GDP) and their alleged, more specific, implications for the

unemployment rate and the labor market as a whole. For instance, Alesina and Zingales argue that "tax cuts have a much better effect on job creation than highway rehabilitation," but propositions of this sort are virtually untested in the literature.[1]

Advocates of measures geared toward a cut in capital income taxes have mainly proposed two types of intervention. The first is a reduction in capital gains taxes. The idea underlying this proposal is that this recession is unique because it originates from credit markets, where investors are still reluctant to lend to risky firms. A reduction in capital gains taxes would boost the willingness of investors to take risks.[2] Skeptics of this proposal, however, doubt the effectiveness of variations in capital gains taxes, specifically in terms of job creation. The second type of intervention that has been advocated is a reduction in depreciation allowances: firms that purchase new machines and other capital goods would be able to write them off immediately, instead of over many years.[3] Some argue, however, that the latter measure is likely to have a limited impact given the current climate of exceptionally low interest rates. Instead, these analysts insist on options mostly geared toward cuts in payroll taxes.[4] The argument is that a cut in payroll taxes would boost output and employment both by increasing demand for goods and services and by providing incentives for additional hiring. Others also note that firms are hoarding a large share of profits, but still perceive the cost of labor to be too high.[5]

Most of the recent debate on the alleged merits of tax cuts has revolved around whether to extend the tax cuts enacted under President George W. Bush. These tax cuts refer to two laws passed in 2001 and 2003 that reduced tax rates across the board on income, dividends, and capital gains, as well as on other specific categories. The Obama administration has recently passed a temporary two-year extension of most of the Bush cuts as part of a larger economic plan. Supporters of this measure argue that a failure to extend the cuts would have implied an actual increase in taxes for the population as

1. Alberto Alesina and Luigi Zingales, "Let's Stimulate Private Risk Taking," *Wall Street Journal*, 21 January 2009. p. A15.

2. This argument is made, for instance, by Alesina and Zingales in the *Wall Street Journal* editorial cited above.

3. See, for instance, the *Wall Street Journal* editorial by R. Glenn Hubbard, September 10, 2010.

4. CBO (2010).

5. See, for instance, Nouriel Roubini, "What America Needs Is a Payroll Tax Cut," *Washington Post*, 17 September 2010.

a whole by the end of 2010.[6] According to the Congressional Budget Office, however, extending all of the Bush tax cuts may have little bang for the buck, the equivalent of a 10- to 40-cent increase in GDP for every tax dollar foregone. The argument (a classic one) is that the Bush tax cuts mostly go to higher-income households, who have a relatively low marginal propensity to consume.[7] Of eleven potential stimulus policies recently examined by the CBO, an extension of all of the Bush tax cuts seems to imply the lowest stimulus per tax dollar foregone.[8] This has led some analysts to argue that the government could have more effectively stimulated the economy by letting the high-income tax cuts expire and using those savings for a combination of a job-creation tax credit and continued state fiscal assistance, which would have allegedly generated "three times as much additional economic activity as using them to extend the high-income tax cuts" (Marr, 2010).[9] Taking the CBO estimates literally, each of these measures is "estimated" to have roughly about three times the impact on GDP as continuing the Bush tax cuts.[10]

Different views about the extension of the tax cuts also depend on the perceived tradeoff between stimulus today and sustainability tomorrow. As reported by Gale and Harris (2010), former Obama administration budget director Peter Orszag has endorsed extending the Bush tax cuts for both middle-income taxpayers and the wealthy, but only for two years: temporary extension of the tax cuts "would keep the economy humming during the recovery," but a more permanent extension of the tax cuts, even if limited to middle-income households, "is simply unaffordable because of the impact on the deficit." Alan Greenspan, former chairman of the U.S.

6. For instance, Rep. McConnell has reportedly said that "only in Washington could someone propose a tax hike as an antidote to a recession." Some Senate Democrats such as Kent Conrad of North Dakota, Evan Bayh of Indiana, and Ben Nelson of Nebraska have also argued "against raising taxes on anyone during a fragile economic recovery" (Gale and Harris, 2010). Similarly, Bill Rys, tax counsel for the National Federation of Independent Business, a small-business group, has argued that "the best thing to do is to get rid of uncertainty, and that includes the cliff we're falling off with all these [tax] provisions that are expiring" (J. Weisman and J. D. McKinnon, "Obama to Push Tax Break," *Wall Street Journal*, 6 September 2010).

7. In work in progress, Monacelli and Perotti (2010) explore (both empirically and theoretically) the issue of whether "pro-poor" tax cuts (that is, tax cuts favoring households in the lower brackets of the income distribution) are more expansionary than tax cuts that redistribute in favor of the rich.

8. See CBO (2010, table 1).

9. See also William G. Gale, "Five Myths about the Bush Tax Cuts," *Washington Post*. 1 August 2010.

10. See CBO (2010, table 1).

Federal Reserve, called an extension of the Bush tax cuts without corresponding spending reductions "disastrous."[11]

These quotations do only partial justice to the complex ramifications of the current debate on the appropriate size and composition of the response of fiscal policy to the Great Recession. That debate, however, almost invariably relies on rather unstructured empirical evidence on the effects of tax changes on the macroeconomy, let alone on the labor market. For example, CBO (2010) reports that "low and high estimates of multipliers for a given policy were chosen, on a judgmental basis, to encompass most economists' views about the effects of that type of policy."

As exemplified by the above discussion, tax changes can occur for a variety of reasons, including as an endogenous reaction to the state of the economy (as is mostly the case in the current recession). But to gauge the economic and quantitative significance of any tax measure, one needs to identify those changes that happen for reasons unrelated to current (or anticipated) developments in the economy.

In this paper, we study the effect of *exogenous* variations in taxes on the U.S. unemployment rate and on several other labor market variables. Our estimates are based on a revised version of the Romer and Romer (2010) narrative record of exogenous tax innovations.[12] There are two main differences in our data set relative to that of Romer and Romer: first, while they use data on tax liabilities, we track the quarterly exogenous changes in receipts generated by each tax bill; second, we distinguish between different types of taxes, including personal, corporate, indirect, and social security taxes and several subcomponents of each of these.[13] Using this disaggregation, we begin to address some of the policy issues quoted above, although not yet at the level of detail that one might like: for instance, there is not enough variation in the postwar time series to address issues like the relative merits of capital gains taxation versus employment tax credits.

We also use a different empirical methodology than Romer and Romer. Following Perotti (2010), we show that accounting for the difference between automatic and discretionary tax changes is crucial for obtaining an unbiased measure of the effects of tax changes. By doing so, we find estimates of the effects of tax shocks that are typically in between the extremely large effects estimated by Romer

11. See Gale and Harris (2010).

12. We do not address the distinction between anticipated and unanticipated tax innovations; see Mertens and Ravn (2009).

13. See Perotti (2010) for more details.

and Romer (2010), and the much smaller (and often statistically insignificant) effects estimated by Favero and Giavazzi (2010).

We obtain the following main results. First, an increase in tax liabilities of one percent of GDP has a sizeable positive impact on the unemployment rate and a sizeable negative impact on GDP, hours worked, employment, labor market tightness, and the probability of finding a job. For instance, under our preferred empirical specification, the unemployment rate increases by 0.50 percentage points after six quarters, while GDP falls by 1.2 percent. Second, we find that the data set matters. When we employ the original Romer and Romer (2010) specification but with our data set, the size of virtually all estimated multipliers decline substantially in absolute value. Third, we find that the multiplier on private investment is particularly large and persistent, with investment contracting by about 5 percent after six and twelve quarters. Fourth, the effect on GDP and on labor market variables of shocks to business taxes is typically larger than the effect of shocks to labor income taxes. In the conclusions, we discuss some of the possible theoretical implications of this result.

The outline of the paper is as follows. In the next section, we present our estimation methodology. Section 2 then briefly discusses the data, and section 3 presents the main results. In section 4, we show the effects of the main types of taxes. Section 5 concludes.

1. ESTIMATES OF DISCRETIONARY TAXATION

In this section we introduce our methodology to estimate the effects of discretionary taxation.[14]

1.1 Romer and Romer (2010) and Favero and Giavazzi (2010)

Romer and Romer (2010) estimate an equation of the following type:

$$y_t = a(L)\,\tau_t + \varepsilon_t, \tag{1}$$

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14. See Perotti (2010) for more details on the methodology. Chahrour, Schmitt-Grohé, and Uribe (2010) use a dynamic stochastic general equilibrium (DGSE) model to compare a tax shock identification strategy based on a structural vector auto regression (SVAR) to one based on narrative records. They conclude that the different tax multipliers obtained from the SVAR and narrative approaches do not depend on differences in the transmission mechanism, but rather reflect either a failure to identify the same tax shock or small sample uncertainty.

where y_t is the variable of interest, τ_t is a measure of tax shocks constructed by Romer and Romer based on the original documentation accompanying tax bills, and $a(L)$ is a lag polynomial of order J (in Romer and Romer, $J = 13$, that is, $a(L)$ includes powers 0 to 12 of the lag operator L). For future reference, we call this the Romer-Romer one-equation specification. Romer and Romer typically find that in response to a tax shock of 1 percentage point of GDP, output declines by up to three percent within three years. Many economists consider these effects to be implausibly large.

Favero and Giavazzi (2010) argue that these results are due to an erroneous specification of the regression to be estimated. They argue that equation (1) cannot be derived from the correct truncated moving average representation of any underlying vector autoregression (VAR). Let the vector $\tilde{\mathbf{X}}_t$ include n endogenous variables of interest—say, output y_t, government spending g_t, the interest rate i_t, government revenues s_t, and a labor market variable such as the unemployment rate. One should then treat the Romer-Romer tax shocks as exogenous variables in a reduced-form VAR in $\tilde{\mathbf{X}}_t$. Formally, this corresponds to the following model:

$$\tilde{\mathbf{X}}_t = B(L)\tilde{\mathbf{X}}_{t-1} + \mathbf{\Gamma}\tau_t + \tilde{\mathbf{u}}_t, \tag{2}$$

where $B(L)$ is a lag polynomial of order 4, $\mathbf{\Gamma}$ is a $(n-1)$ vector, and $\tilde{\mathbf{u}}_t$ is a vector of reduced-form residuals. Favero and Giavazzi estimate equation (2) by ordinary least squares (OLS), and they argue that the correct impulse responses are obtained by simply tracing the dynamic effects of a shock to τ_t of one percentage point of GDP. For future reference, we call equation (2) the Favero-Giavazzi OLS specification.

If one is only interested in the effects of the Romer-Romer tax shocks, there is no need to go beyond this reduced-form specification, provided that Romer and Romer's two identifying assumptions are satisfied: τ_t is orthogonal to $\tilde{\mathbf{u}}_t$, and τ_t is unpredictable using lagged variables in the information set of the econometrician. Favero and Giavazzi find that a one-percentage-point-of-GDP realization of τ_t causes output to decline by less than one percent, and the effect is often insignificant.

The correct truncated moving average representation of equation (2) is

$$\tilde{\mathbf{X}}_t = C(L)\tau_t + D(L)\tilde{\mathbf{X}}_{t-J} + \tilde{\eta}_t, \tag{3}$$

where $C(L)$ is a lag polynomial of order J, $D(L)$ is of the same order as $B(L)$, and $\tilde{\eta}_t$ is a moving average of $\tilde{\mathbf{u}}_t$. As Favero and Giavazzi (2010) argue, a comparison of equation (1) with equation (3) shows that Romer and Romer's equation (1) does not correspond to the first equation of the truncated moving average representation of the original VAR, because Romer and Romer omit the lagged values of the endogenous variables.[15]

1.2 Discretionary and Automatic Tax Changes

Perotti (2010) argues that the specification adopted by Favero and Giavazzi is incorrect if one wants to capture the dynamic effects of the Romer-Romer tax shocks. Changes in tax revenues are the combination of discretionary changes to taxation (which reflect intentional actions by the policymakers, like changes in tax rates, depreciation allowances, deductions, and so on) and automatic changes to revenues (which reflect the effects of output, inflation, and so forth on tax revenues), for given tax rates. Therefore, tax revenues can be given by the following expression:

$$s_t = \underbrace{\tau_t}_{\text{discretionary}} + \underbrace{(\phi \mathbf{X}_t + \mu_t)}_{\text{automatic}}, \tag{4}$$

where τ_t (that is, the Romer-Romer tax shocks) captures the changes in discretionary taxation, $\mathbf{X}_t$ is a vector of endogenous variables that includes the same variables as $\tilde{\mathbf{X}}_t$ except s_t, and ϕ is a $[1 \times (n-1)]$ vector of coefficients. For simplicity, we refer to the term $\phi \mathbf{X}_t + \mu_t$ as the automatic component of tax changes.

Perotti (2010) argues that the discretionary and the automatic components of changes in tax revenues are likely to have different effects on output. There are at least two reasons for this. First, discretionary changes are more distortionary, because they consist of changes in both tax rates and tax rules. Second, discretionary tax changes are likely to be more persistent. To see this, suppose taxation is defined with reference to trend or potential output, so that deviations of output from the reference level sum to zero over the cycle. In this case, if agents are not liquidity constrained, the automatic component of taxation should have no effect on the

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15. Romer and Romer also estimate a version of (1) that includes lags 1 to 4 of y_t, but this does not address the criticism raised by Favero and Giavazzi.

agents' behavior, because neither tax rates nor the present value of tax payments change.[16]

In light of this distinction, the correct specification of the model is not equation (2), but equation (4) combined with the VAR:

$$\mathbf{X}_t = B(L)\mathbf{X}_{t-1} + C(L)\tau_t + D(L)(s_t - \tau_t) + u_t, \tag{5}$$

where $D(L)$ is a lag polynomial of order 5. Combining equations (4) and (5) yields

$$(I - \mathbf{D}_0\phi)\mathbf{X}_t = [B(L) + \phi D'(L)]\mathbf{X}_{t-1} + C(L)\tau_t + D(L)\mu_t, \tag{6}$$

where $\mathbf{D}_0$ is the vector of coefficients of $D(L)$ when $L = 0$ and $D'(L)$ is a lag polynomial of order 4, defined as $D(L) - \mathbf{D}_0$.

After rearranging, equation (6) yields:

$$\mathbf{X}_t = F(L)\mathbf{X}_{t-1} + G(L)\tau_t + H(L)\mu_t + v_t, \tag{7}$$

where

$$F(L) \equiv (I - \mathbf{D}_0\phi)^{-1}[B(L) + \phi D'(L)],$$

$$G(L) \equiv (I - \mathbf{D}_0\phi)^{-1}C(L),$$

$$H(L) \equiv (I - \mathbf{D}_0\phi)^{-1}D(L), \text{ and}$$

$$v_t = (I - \mathbf{D}_0\phi)^{-1}u_t.$$

Mertens and Ravn (2010) perform an OLS regression of $\mathbf{X}_t$ on its lags and on τ_t and its lags, thus treating the term $H(L)\,\mu_t + v_t$ in equation (7) as the error term. We refer to the specification in equation (7) as the Mertens-Ravn OLS specification.

The Mertens-Ravn OLS approach gives biased estimates because μ_{t-i} is likely to be correlated with $\mathbf{X}_{t-i}$. The solution is to take μ_t and its lags out of the error term and include them explicitly as regressors in equation (7). This can be done through an instrumental variable estimation of equation (4), which allows us to recover an

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16. One could argue that a purely cyclical source of changes in revenues could matter if individuals are moved into different tax brackets, so that the average marginal income tax rate changes. This effect is however likely to be second order.

estimate of μ_t.[17] The natural instruments for the variables in $\mathbf{X}_t$ in equation (4) are lags of $\mathbf{X}_t$ and lags of τ_t. We call this the Mertens-Ravn IV specification. The Mertens-Ravn IV and OLS estimates are similar, and both display much stronger effects on all endogenous variables than the Favero-Giavazzi OLS specification. Both these observations are relatively easy to explain in our context.

To illustrate why the Favero-Giavazzi OLS specification is likely to lead to attenuated estimates of the effects of a tax shock, we use equation (7) to replace the vector $\mathbf{X}_t$ in equation (4). This gives

$$s_t = \phi F(L)\mathbf{X}_{t-1}[1 + \phi G(L)]\tau_t + [1 + \phi H(L)]\mu_t + \phi v_t. \qquad (8)$$

If we stack equations (7) and (8) and then collapse the polynomials in μ_t and the terms in v_t in the error terms of each equation of the resulting system, we can almost reproduce the Favero-Giavazzi reduced-form specification of equation (2), except that the lags of s_t in the latter are replaced by lags of τ_t in equation (8).

Consider therefore an OLS estimation of the Favero-Giavazzi specification (2), when the true model is given by equations (7) and (8). There are two sources of bias in the Favero-Giavazzi OLS approach. The first is the same as in the Mertens-Ravn OLS approach: the lags of μ_t are likely to be correlated with the lags of $\mathbf{X}_t$. The second source of bias stems from the inclusion of lags of s_t instead of lags of τ_t. The difference between s_{t-i} and τ_{t-i} has two components. The first is $\phi \mathbf{X}_{t-i}$, which gets incorporated in the polynomial $\phi F(L)\mathbf{X}_{t-1}$ on the right-hand side of equation (8) and does not cause any harm; the second component, μ_{t-i}, introduces a classic error-in-variable problem, which typically biases estimated coefficients toward zero. The solution to both problems consists once again in taking μ_t and its lags out of the error term, generating the Favero-Giavazzi IV estimates. In fact, the Favero-Giavazzi IV estimates and the Mertens-Ravn IV estimates are numerically identical if exactly the same instruments are used to estimate equation (4),.

To illustrate why the Mertens-Ravn OLS and IV estimates are very close to each other, we set $D(L) = 0$ in equation (5), so that automatic tax changes have no effects. In this case, the Mertens-Ravn OLS responses are consistent because lagged values of μ_t do not appear in the error term. Thus, the fact that the Mertens-Ravn

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17. This requires a third identifying assumption, in addition to Romer and Romer's assumptions: namely, v_t should be uncorrelated with current and past values of μ_t.

OLS and IV responses are similar is an indication that the effects of automatic tax changes are negligible.

Favero-Giavazzi OLS responses continue to be inconsistent, because this specification uses lags of s_t instead of τ_t. If instead $D(L) = C(L)$, so that the two components of tax changes have the same effects, then the Favero-Giavazzi OLS responses are consistent, because s_t is the right variable to have in the system. The intuition is clear: in this case, there is no need to decompose lags of s_t into the discretionary and automatic components.

1.3 Back to Romer and Romer

The original Romer-Romer approach, as exemplified by equation (1), has problems in small samples because it omits some terms of the truncated moving average representation. Favero and Giavazzi's version of the truncated moving average representation, equation (3), includes these terms but has the problem that it does not allow for different effects of the discretionary and automatic components of tax changes. The correct truncated moving average representation can be derived from equation (7) and takes the following form:

$$\mathbf{X}_t = V(L)\tau_t + W(L)\mathbf{X}_{t-J} + \eta_t, \tag{9}$$

where $V(L)$ is a lag polynomial of order J, $W(L)$ is of the same order as $B(L)$, and η_t is a moving average of μ_t and v_t. Henceforth we call this the augmented Romer-Romer OLS specification. This specification differs from equation (3) in that it does not includes s_t among the endogenous variables.

Once again, an OLS estimate of equation (9) generates biased impulse responses because of the correlation between lags of μ_t in the error term and lags of $\mathbf{X}_t$. The solution, as usual, is to take lags of μ_t out of the error term; we denote the resulting specification the augmented Romer-Romer IV specification.

2. THE DATA

Perotti (2010) presents a new set of data that extends the Romer-Romer data in several dimensions. That paper provides full details on the construction of the data; here we summarize

the main points. First, the aggregate tax shocks are divided into four main categories (personal, corporate, social security, and indirect taxes), as well as several subcategories. We exploit this disaggregation in section 4. Second, whereas Romer and Romer collect data on liabilities, Perotti (2010) collects data on both receipts and liabilities, whenever the distinction is made in the sources. In this paper, we use receipts, although the difference in effects between receipts and liabilities is small.

Third, Romer and Romer typically report the effect of a tax legislation as the first full-year effect of liability changes after enactment, and they attribute that number to the quarter of enactment. There are cases, however, in which a tax legislation manifests its effects gradually over several quarters. For instance, accelerated depreciation typically causes a large change in the time profile of receipts, but a small change in their present discounted value: receipts decline initially but increase later. Using the first full-year effect would therefore provide a distorted picture of the effects of the tax measure. Whenever possible, Perotti (2010) follows the effects of tax legislation over time.

Finally, while Romer and Romer attribute all the effects of retroactive changes to the first quarter of enactment, Perotti (2010) keeps track of the effects of retroactive measures over time. This can make a considerable difference, particularly in the case of corporate income taxation.

3. ESTIMATES

In this section, we present the results of our empirical analysis, based on a battery of alternative specifications and decompositions of the data set.

3.1 Specifications

To summarize the discussion of the previous section, we estimate the following four specifications:

—Romer-Romer one-equation specification:

$$z_t = a(L)\tau_t + \varepsilon_t, \tag{10}$$

where $a(L)$ is of order 13 and z_t is the variable of interest;

—Augmented Romer-Romer specification:

$$\mathbf{X}_t = A(L)\tau_t + B(L)\mathbf{X}_{t-13} + \varepsilon_t, \tag{11}$$

where $A(L)$ is of order 13 and $B(L)$ of order 4 and where the vector $\mathbf{X}_t$ includes the log change of real per capita output Δy_t, the log change of real primary government spending per capita Δg_t, the first difference of the interest rate Δi_t, and the first difference of a labor market variable, each considered in turn (see more below);[18]

—Favero-Giavazzi specification:

$$\tilde{\mathbf{X}}_t = \alpha\tau_t + B(L)\tilde{\mathbf{X}}_{t-1} + \varepsilon_t, \tag{12}$$

with $B(L)$ of order 4; and

—Mertens-Ravn specification:

$$\mathbf{X}_t = A(L)\tau_t + B(L)\mathbf{X}_{t-1} + \varepsilon_t, \tag{13}$$

where $A(L)$ and $B(L)$ are of order 5 and 4, respectively.

All four specifications also include a constant. To maximize comparability with Romer and Romer (2010), in the baseline case we estimate all these specifications in first differences. All the specifications, except the Romer-Romer one-equation specification, are estimated by both OLS and IV, as discussed above. In the latter case, the set of regressors includes the moving average (lags 0 to 4) of the series μ_t obtained by IV estimation of equation (4), using as instruments lags 1 to 4 of the variables included in the vector $\mathbf{X}_t$, and lags 0 to 4 of τ_t.[19]

In all cases the initial shock is a realization of the Romer-Romer tax shock of 1 percentage point of GDP. We report both 68 percent confidence bands, which have been used extensively in the recent empirical fiscal policy literature, and the more traditional 95 percent confidence bands.[20] Standard errors are obtained by bootstrapping with 1,000 replications. We display both the point estimates of the

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18. As suggested above, this is a multidimensional extension of the original Romer-Romer one-equation regression, with the addition of lags 13 to 16 of the endogenous variables, as it should be if the moving average representation is truncated correctly.

19. In the case of the Favero-Giavazzi specification, the set of instruments also includes lags 1 to 4 of s_t and only lag 0 of τ_t.

20. In their original work, Romer and Romer mostly display 68 percent confidence bands.

impulse responses and the median response of the replications. In most cases, the two impulse responses are indistinguishable in the figures.

3.1.1 Sample

The sample of Perotti's (2010) data on τ_t is 1945:1 to 2008:2 (the sample of Romer-Romer data is 1947:1 to 2006:2). The other constraints on the sample are the series on the log change in GDP, government spending, and revenues per capita, which start in 1948:2.[21] With four lags of the endogenous variables as instruments, the estimated series μ_t starts in 1949:2; since at least four lags of the endogenous variables appear in each specification, the earliest starting date of an IV estimate is 1950:2.

3.1.2 Labor market variables

We consider the following labor market variables: the unemployment rate, the log of unemployment, and the log of the labor force (the latter two variables divided by the population);[22] the probability of finding a job (calculated using data on unemployment and short-term unemployment), labor market tightness (the ratio of vacancies to unemployment), the log of vacancies (as a share of the population), and the separation rate; the log of employment and hours in the private sector and in manufacturing, all as shares of the population;[23] the log of the real product wage in manufacturing and in the business sector;[24] and the markup in manufacturing and in the nonfinancial business sector.

3.2 Results

This subsection presents the results of our estimating the four specifications identified above. For the Romer-Romer one-equation

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21. The national income and product account (NIPA) data on the levels of these variables start in 1947:1, but the Federal Reserve economic data (FRED) on population start in 1948:1. The interest rate is defined as the average cost of servicing the debt, and it is constructed by Favero and Giavazzi (2010) by dividing net interest payments at time t by the federal government debt held by the public at time $t - 1$.

22. Here and in what follows, "population" stands for "population age 16 and above."

23. Total nonfarm employment and civilian employment behave almost exactly like private employment; the same is true for hours.

24. These are obtained by dividing nominal wages by the producer price index.

specification, we only report the multipliers. This allows us to focus on the impulse responses to shocks to taxes for the three main alternative methodologies of interest.

3.2.1 Favero-Giavazzi OLS specification

Figure 1 displays responses from a Favero-Giavazzi OLS specification. Private consumption and private investment all decline, but by much less than estimated by Romer and Romer; GDP even increases slightly, although with very large standard errors. All labor market variables also move very little, and the results are never significant at the 95 percent level of confidence. The unemployment rate increases by a mere 0.15 percentage points at the peak, and the response is entirely insignificant even at the 68 percent level. As we argued above, if the discretionary and automatic components of fiscal policy do indeed have different effects, we would expect an attenuated response to a discretionary tax shock.

Figure 1. Favero-Giavazzi OLS specification
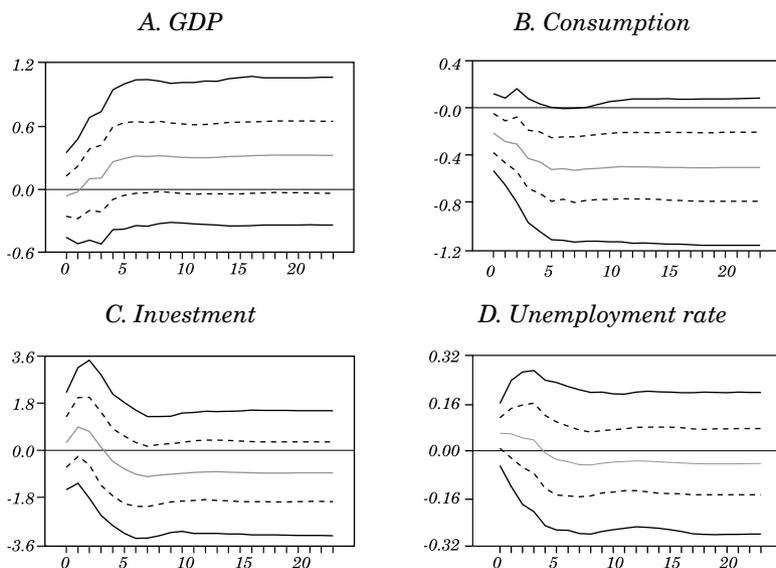
Figure 1. (continued)

E. Unemployment
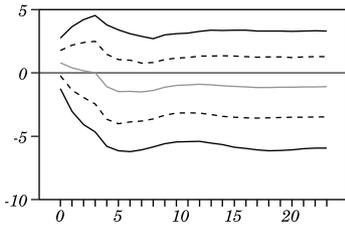
F. Labor Force
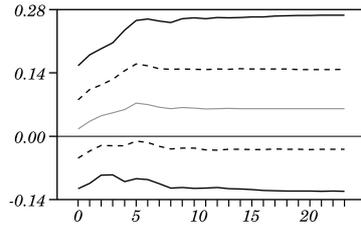
G. Probability of finding a job
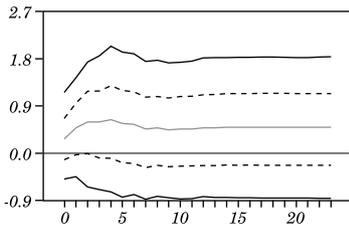
H. Labor market tightness
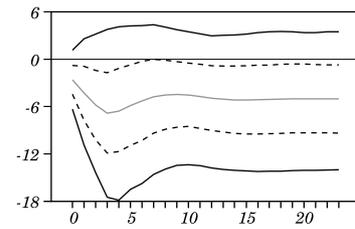
I. Vacancies
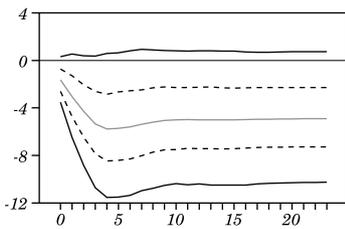
J. Separation rate
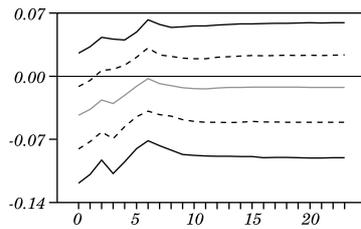
K. Private employment
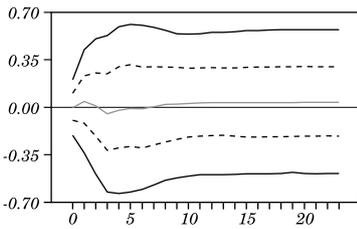
L. Manufacturing employment

Figure 1. (continued)

M. Private hours

N. Manufacturing hours

O. Business sector wage

P. Manufacturing wage

Q. Non-financial business sector markup

R. Manufacture sector markup

——— 95% confidence interval   - - - - 68% confidence interval   ——— Point estimation of the impulse-response function
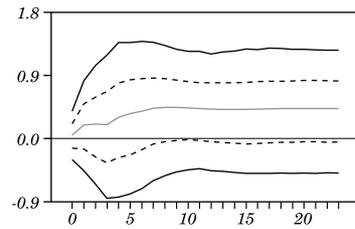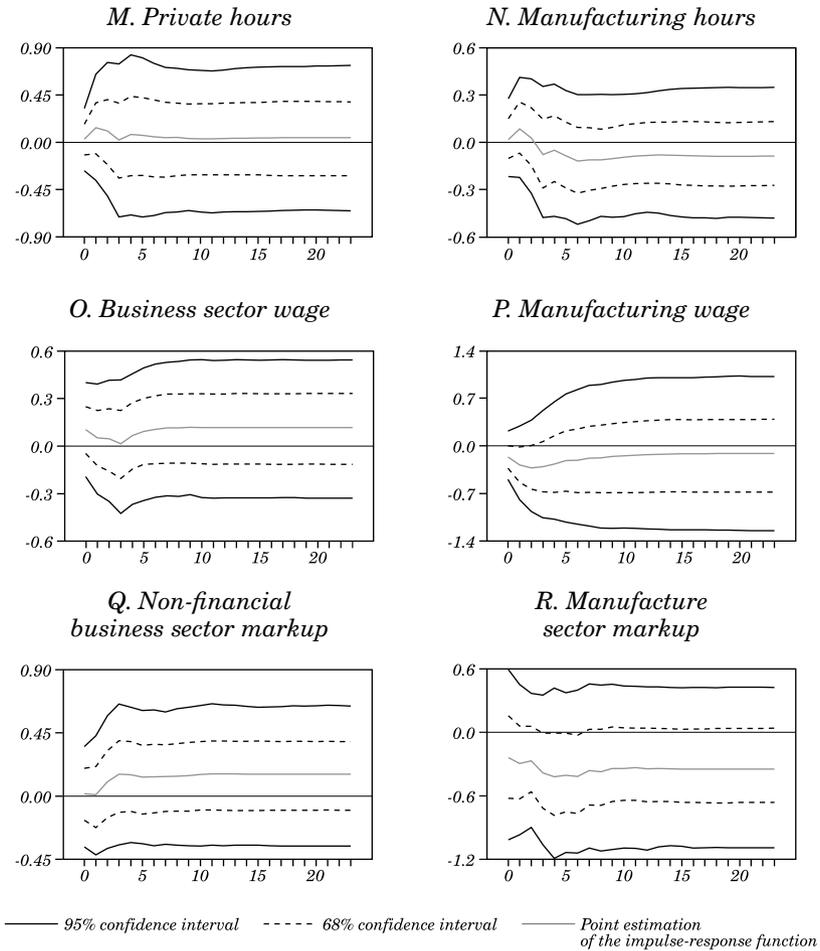
Source: Authors' calculations based on Favero and Giavazzi (2010).

3.2.2 Mertens-Ravn IV specification

Figure 2 displays responses from the Mertens-Ravn IV specification. The responses are much stronger than under the Favero-Giavazzi specification. GDP falls by 1.2 percent after six quarters, less than half the decline estimated by Romer and

Romer, but still much more than the Favero-Giavazzi estimate. Private consumption falls by 0.7 percent and private investment by about 5 percent, which again is in between the Romer-Romer and Favero-Giavazzi estimates. The standard error bands are now much tighter. The GDP and private investment responses are significant at the 95 percent level, while the consumption response is only significant at the 68 percent level. Private investment also declines, but the response is significant only at the trough of 3 percent after three quarters.

Figure 2. Mertens-Ravn IV Specification

A. GDP

B. Consumption

C. Investment

D. Unemployment rate

E. Unemployment level (log)

F. Labor force
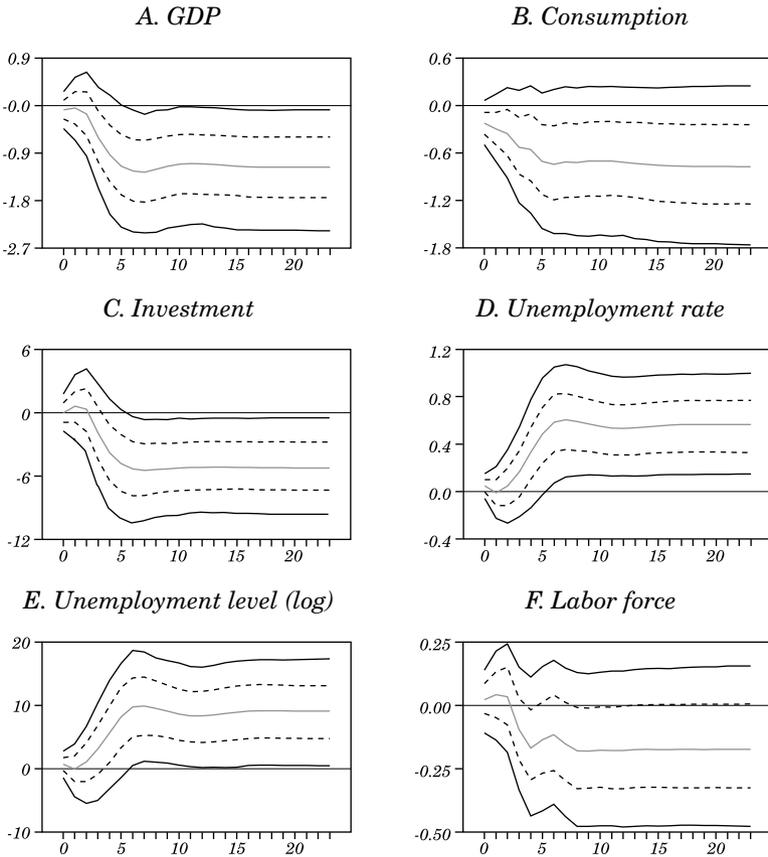
Figure 2. (continued)

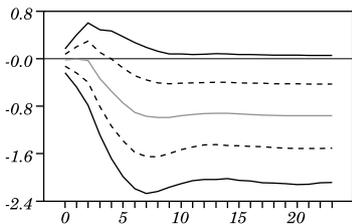### G. Job finding probability
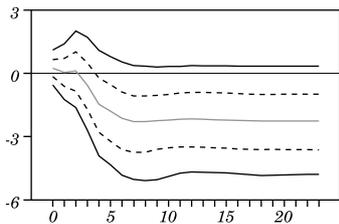
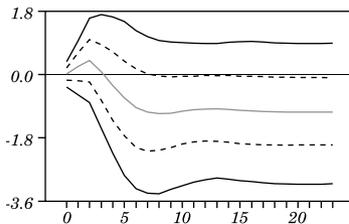### H. Labor market tightness
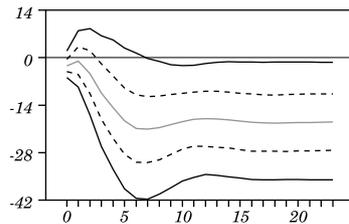
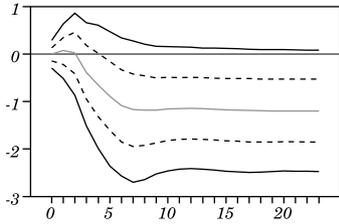### I. Vacancies (log)
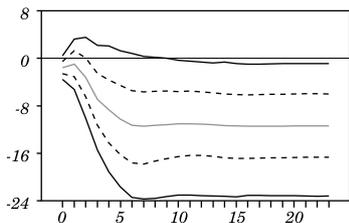
J. Separation rate
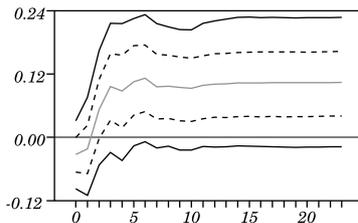
K. Private sector employment
(share of population)

L. Manufacture sector employment
(share of population)

M. Private sector hours
(share of population)

N. Manufacture sector hours
(share of population)

Figure 2. (continued)

O. Business sector wage

P. Manufacture sector wage /
Producer price index

Q. Non-financial
business sector markup

R. Manufacture
sector markup

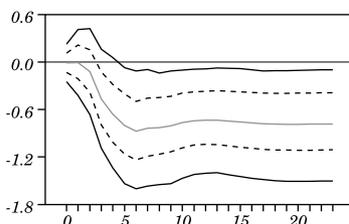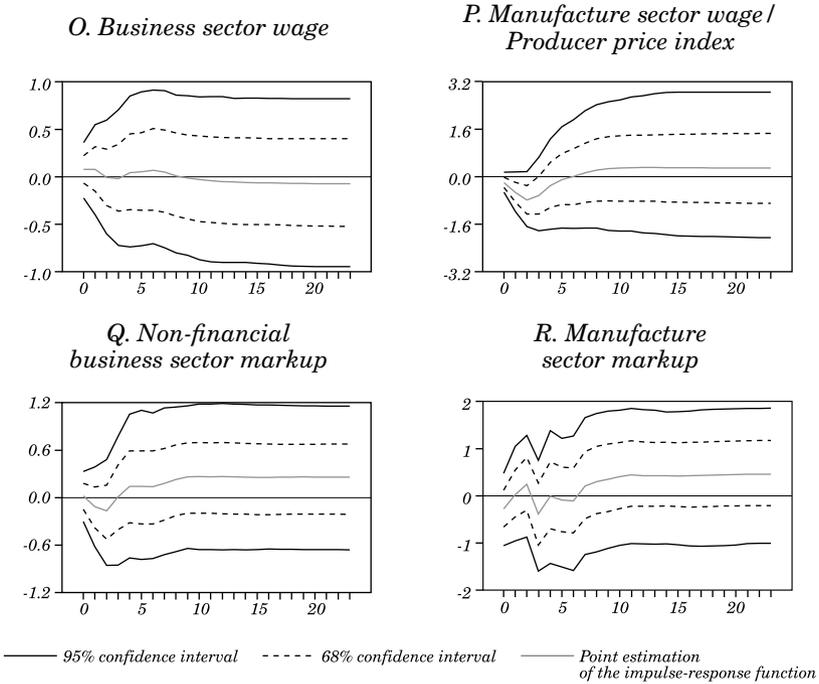——— *95% confidence interval*　- - - - *68% confidence interval*　——— *Point estimation
of the impulse-response function*

Source: Authors' calculations based on Mertens and Ravn (2009).

Qualitatively, all labor market variables move in a direction that is economically meaningful.[25] In all cases (with the exception of the real wage and the markup), the responses are significant or nearly significant at the 95 percent level, usually after a few quarters. The unemployment rate increases gradually, reaching a peak of about 0.6 percentage points after six quarters and then stabilizing at that level. Panels E and F show that most of the action comes from the increase in unemployment, but there is also a decline of the labor force participation by about 0.2 percent, although the drop is significant only at the 68 percent level.

25. We do not employ a formal theoretical model in this version of the paper, but these results are all qualitatively consistent with a benchmark real business cycle (RBC) model with search and matching frictions in the labor market. For example, Monacelli, Perotti, and Trigari (2010) use an RBC model to study the effects of government spending. See more below on this point.

The job-finding probability falls gradually, reaching a peak reduction of about three percentage points after two years. Similarly, labor market tightness falls gradually by almost 20 percent after two years. This decline is due in almost equal measure to a decrease in vacancies and to an increase in unemployment (see panel E and panel I). The separation rate increases by about 0.15 percentage point after one year. This implies that both the hiring and the separation margin contribute considerably to the decrease in employment.

Panels K through N display the responses of private and manufacturing employment and hours. Hours decline by about 1 percent in both sectors; both are significant at the 95 percent level. Virtually all the response of hours is due to the extensive margin: employment tracks hours almost exactly. Finally, the real wage and the markup in manufacturing and in the business sector (panels O through R) move little, and the standard errors tend to be large.

The OLS estimates of all these responses obtained under the Mertens-Ravn specification (not shown) are very similar to the IV estimates displayed here; as discussed above, this is consistent with a small effect of the automatic component of tax changes, captured by $D(L)$. In contrast, the IV responses of the Favero-Giavazzi specification (also not shown) are different from the corresponding OLS responses displayed in figure 1: this is consistent with a large difference between the effects of the discretionary and automatic components of tax changes.[26]

3.2.3 Augmented Romer-Romer moving average specification

For comparison, we display the responses of the augmented Romer-Romer OLS moving average specification in figure 3. This is a multidimensional extension of the original Romer-Romer one-equation regression. The responses are often slightly stronger than the Mertens-Ravn IV responses, and the standard error bands tighter. In particular, unemployment increases more, and hours, employment, and GDP decline more. There is also more evidence of an increase

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26. As discussed above, Favero-Giavazzi IV responses are very similar to Mertens-Ravn IV responses, and they are numerically identical if the same instruments are used to estimate equation (4).

in the product wage, particularly in manufacturing, where it rises by 2 percent after two years and is significant at the 95 percent level. These results are consistent with Perotti (2010), who shows that Mertens-Ravn IV responses of output are often in between the large responses estimated by Romer and Romer (based on a single-equation approach rather than an augmented Romer-Romer specification as here) and the small responses estimated by Favero and Giavazzi.

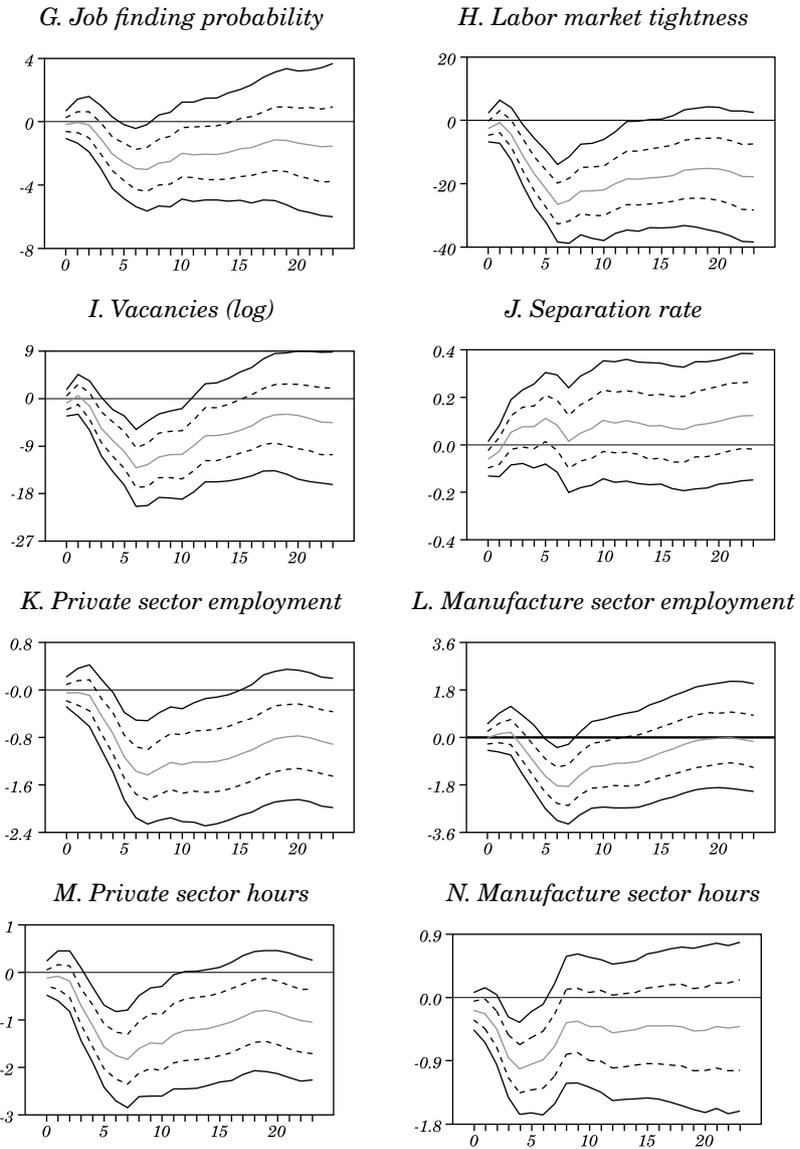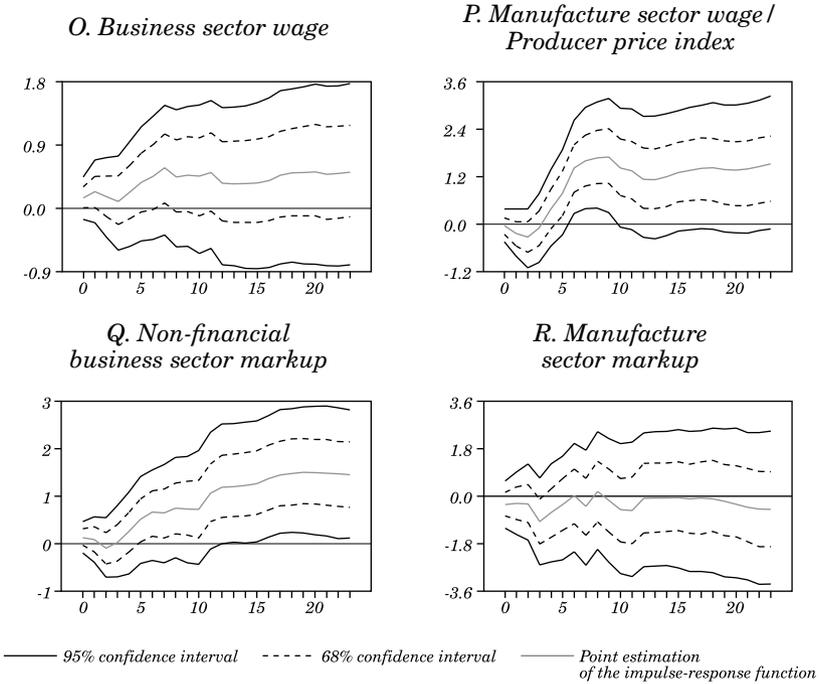Figure 3. Augmented Romer and Romer OLS Specification

A. GDP

B. Consumption

C. Investment

D. Unemployment rate

E. Unemployment level

F. Labor force

Figure 3. (continued)

G. Job finding probability

H. Labor market tightness

I. Vacancies (log)

J. Separation rate

K. Private sector employment

L. Manufacture sector employment

M. Private sector hours

N. Manufacture sector hours

Figure 3. (continued)

O. Business sector wage

P. Manufacture sector wage /
Producer price index

Q. Non-financial
business sector markup

R. Manufacture
sector markup

———— *95% confidence interval*   - - - - - *68% confidence interval*   ———— *Point estimation*
of the impulse-response function

Source: Authors' calculations based on Romer and Romer (2008).

3.2.4 Multipliers

Table 1 summarizes the main results in terms of tax multipliers. It displays the point estimates of the impulse responses of the main variables of interest, at six and twelve quarters, for the three alternative methodologies: Favero-Giavazzi OLS, Mertens-Ravn IV, and augmented Romer-Romer OLS moving average. We also show the responses from the Romer-Romer one-equation specification, estimated both with the original Romer-Romer data and with our data. Recall that the underlying tax shock is normalized to 1 percentage point of GDP.

Four observations stand out. First, the Romer-Romer one-equation specification delivers much stronger responses than the other three specifications. With the original Romer-Romer data on the

Table 1. Tax Multipliers under Alternative Specifications[a]

| Variable and response time | Romer-Romer OLS one-equation | | Augmented Romer-Romer OLS | Favero-Giavazzi OLS | Mertens-Ravn IV |
	Romer-Romer data	Our data			
Unemployment rate					
Six quarters	0.32 *	0.30 *	0.70 **	−0.05	0.49 *
Twelve quarters	1.10 *	0.67 **	0.74 **	−0.05	0.54 **
Job finding probability					
Six quarters	−1.98 *	−0.78	−2.56 **	0.57	−1.79 *
Twelve quarters	−4.76 *	−2.51 *	−2.09 **	0.46	−2.17 *
Private employment					
Six quarters	−0.44 *	−0.59 *	−1.13 **	−0.01	−0.75 **
Twelve quarters	−2.07 *	−1.35 **	−1.22 **	0.03	−0.94 *
Business wage					
Six quarters	−0.58 *	0.11	0.37	0.09	0.05
Twelve quarters	−0.51 *	0.17	0.51	0.12	0.04
Private investment					
Six quarters	−3.56 *	−1.63	−5.58 **	−0.71	−4.67 *
Twelve quarters	−9.69 *	−3.30	3.01	−0.84	−5.11 *
GDP					
Six quarters	−1.17 **	−0.82 *	−1.52 **	0.34	−1.15 *
Twelve quarters	−2.74 **	−1.73 **	−1.54 **	0.35 *	−1.10 *

Source: Authors' elaboration.
* Statistically significant at the 32 percent level. ** Statistically significant at the 5 percent level.
a. See section 3.1 for the details of the alternative specifications.

tax shocks, the unemployment effect at twelve quarters is 1.10, the GDP effect -2.74 (as in Romer and Romer, 2010), and the investment effect an impressive -9.69 percent. These numbers are about two to three times larger than the Mertens-Ravn IV effects.

Second, the tax data do make a difference: when we use our own estimates of the tax shocks, the effects on virtually all variables decline in absolute value, although they usually remain larger than in the Mertens-Ravn IV specification. For the rest of the results, we use our estimates of the tax shocks.

Third, the augmented Romer-Romer specification (that is, the multivariate extension of the Romer-Romer one-equation specification) still tends to deliver higher estimates of the unemployment and GDP effects than the Mertens-Ravn IV specification. In contrast, the Favero-Giavazzi specification features much smaller and often insignificant multipliers. Under our preferred specification (Mertens-Ravn IV), the unemployment rate rises by 0.54 percentage points after six quarters, whereas GDP falls by 0.93 percent; the responses at twelve quarters are almost identical. Noticeably, both the unemployment and the GDP multipliers estimated under the Mertens-Ravn IV specification are a bit smaller than the corresponding multipliers of government spending that we estimated in Monacelli, Perotti, and Trigari (2010).

Fourth, the investment multiplier is sizeable both in the Mertens-Ravn IV specification and in the augmented Romer-Romer specification (after six quarters, -3.88 percent and -2.93 percent, respectively, although in the latter case it is estimated rather imprecisely). Once again, the effect on investment under the Favero-Giavazzi specification is smaller and not statistically significant at both horizons.

4. LABOR AND CORPORATE INCOME TAXES

One benefit of the dataset we use is that it allows us to distinguish between different types of taxes. In particular, we identified four main tax categories and several subcategories:

—Personal taxes (which disaggregates into the subcategories of tax rates, deductions and allowances, tax credits, capital gains tax, depreciation, earned income tax credit, rebates, estate and gift taxes, and other taxes);

—Corporate income taxes (which disaggregates into tax rates, employment credit, investment tax credit, depreciation, and other taxes);

—Indirect taxes; and

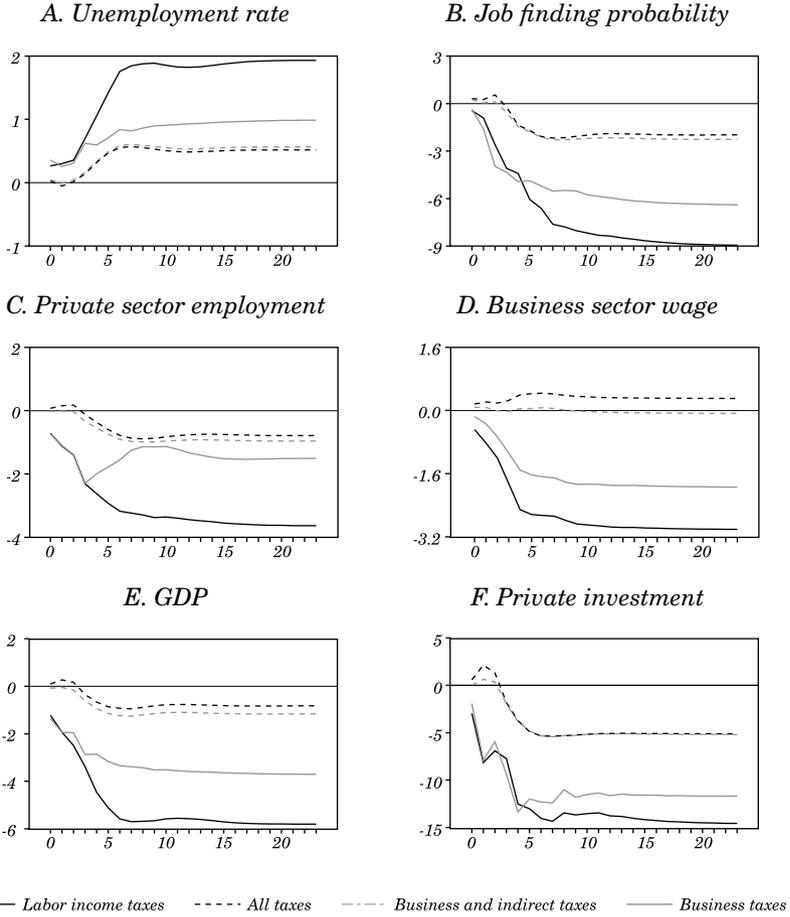—Social security taxes (including tax rates, earnings base, and other taxes).

The sum of all these items is the aggregate taxes that we have used in the exercises so far. We now regroup these taxes into three main categories:

—Labor income taxes: personal income taxes (excluding capital gains taxes and depreciation allowances) and social security taxes;

—Business taxes I: corporate income taxes, personal capital gains, and personal depreciation allowances; and

—Business taxes II: business taxes I plus indirect taxes.

Figure 4 displays the results. We only display the responses of the main variables: for instance, we have seen that the impulse responses of tightness and vacancies track the response of the job-finding probability very closely, so we only display the latter. The effects of labor income taxes are virtually identical to those of all taxes combined. In contrast, the effects of the two types of business taxes are stronger, particularly under the second definition; the first definition tracks the second closely in the first year, but it then returns to the stochastic trend more quickly. Under the second definition, a shock to business taxes raises the unemployment rate by twice as much as a similar shock to labor income taxes; it also causes a larger decline in the job-finding probability, employment in the private sector, GDP, and private investment by twice as much or more. Finally, it causes a 3 percent decline in the business sector wage, which does not move in response to a shock to labor taxes or total taxes.

Figures 5 and 6 display the responses to shocks to labor income taxes and to the second definition of business taxes, respectively, now including their 68 and 95 percent standard error bands. The figures also display the responses to shocks to total taxes (the dashed line). Here again, the responses to labor income taxes differ minimally from the responses to total taxes, and the standard errors are only slightly larger. With corporate income taxes, the responses are always significant at the 95 percent level; they are also significantly different from the responses to total taxes at the same level of confidence.

Figure 4. Different Types of Taxes: Mertens-Ravn IV Specification

A. Unemployment rate

B. Job finding probability

C. Private sector employment

D. Business sector wage

E. GDP

F. Private investment

Labor income taxes ——— All taxes - - - - Business and indirect taxes - · - · Business taxes ———

Source: Authors' calculations based on Mertens and Ravn (2009).

Figure 5. Labor Taxes: Mertens-Ravn IV Specification[a]

A. Unemployment rate

All taxes

Labor taxes

B. Job finding probability

Labor taxes

All taxes

C. Private sector employment

Labor taxes

All taxes

D. Business sector wage

Labor taxes

All taxes

E. GDP

Labor taxes

All taxes

F. Private investment

Labor taxes

All taxes

——— 95% confidence interval   - - - - 68% confidence interval   ——— Point estimation
of the impulse-response function
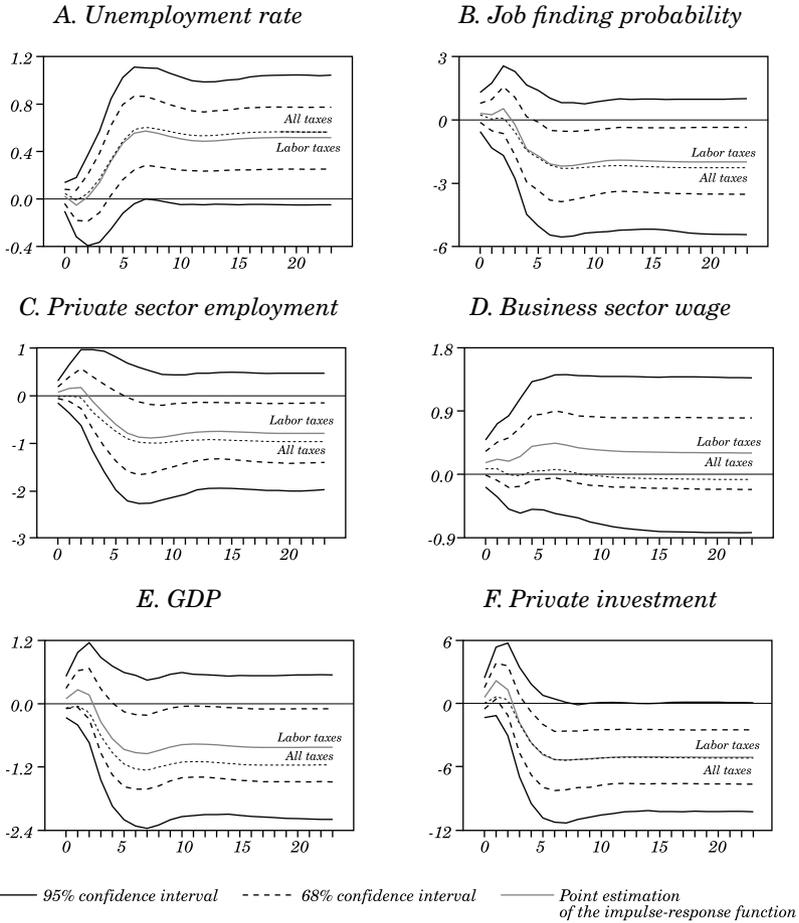
Source: Authors' estimations.
a. The dashed lines graph the responses to shocks to total taxes.

Figure 6. Business Taxes: Mertens-Ravn IV Specification[a]

A. Unemployment rate

B. Job finding probability

C. Private employment

D. Business sector wage

E. GDP

F. Private investment

———— 95% confidence interval   - - - - 68% confidence interval   ———— Point estimation
of the impulse-response function

5. Conclusions

We have investigated the effects of exogenous variations in taxes on a series of macroeconomic variables, with special emphasis on the unemployment rate and the labor market. Our analysis differs from the seminal contribution of Romer and Romer (2010) in three main respects: first, we extend their data set of narrative records of exogenous tax innovations; second, we show that methodological assumptions on both the specification and the estimation of the empirical model are crucial for quantifying the size of the tax multipliers; and third, we devote special attention to the labor market implications of the changes in taxes.

We have shown that an increase in tax receipts of one percent of GDP has a sizeable positive impact on the unemployment rate and a negative impact on hours worked, labor market tightness, and the probability of finding a job. The negative effect on GDP is also sizeable, but in the mid-range of other values found in the literature. We have shown that this depends on a series of methodological details, involving both the econometric specification and the estimation method. We have also shown that the unemployment multiplier is larger for business taxes than for personal income taxes, although the former is estimated a bit more imprecisely than the latter.

Obtaining larger unemployment multipliers from business taxes than from personal income taxes poses a series of interesting theoretical challenges. In Monacelli, Perotti, and Trigari (2010) we build an RBC model with search and matching frictions to analyze the effects of variations in government purchases. In that model, we establish that changes in government spending affect the hiring rate via variations in the value of nonwork relative to work activity, which in turn affects the surplus from the job matching process. Importantly, the relative value of nonwork activity captures not only the marginal value of leisure, but also the broader value of all nonmarket activities, including home production and unemployment benefits.

One can employ the same model to analyze the labor market effects of exogenous changes in a variety of distortionary taxes. For example, variations in wage income taxes would also affect the hiring rate via their effect on the relative value of nonwork activity. However, changes in employers' payroll taxes, which are classified among the business taxes in our empirical analysis, would have exactly the same effect on surplus and hiring. Nash bargaining renders those two taxes effectively undistinguishable in the model.

Several other tax categories can be modeled within the baseline theoretical framework. For example, we can introduce investment and employment tax credits as directly affecting the cost of hiring a worker (as either a subsidy per vacancy or a subsidy per new hire). More generally, mapping our tax categories in the data into model counterparts requires some thinking, but the model easily lends itself to this exercise. Furthermore, while there is already extensive work on the steady-state effects of various taxes and subsidies in the baseline search and matching model, the study of their dynamic effects over the business cycle is quite limited. We plan to explore these issues in future research.

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