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Tax Progressivity, Economic Booms, and Trickle-Up Economics*

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Abstract

We propose a method to decompose changes in the tax structure into a component measuring the level of taxes and a component orthogonal to the level that measures progressivity. While our focus is on the progressivity results, we find that the level shock is similar to standard tax shocks found in the empirical literature in that a rise in the level is contractionary. An increase in tax progressivity sets off an economic boom. Those at the bottom of the income distribution (who are constrained hand-to-mouth consumers) set off a consumption boom that expands the overall economy. Those at the top of the income distribution benefit disproportionately from expansions, and their income gains more than offset the increases in tax from higher marginal rates. The net result is that an increase in progressivity leads to an increase in inequality, not a decrease as conventional wisdom would suggest. We interpret these results as evidence in favor of trickle-up, not trickle-down, economics.

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1 Introduction

Over the last 40 years, marginal tax rates for the top income brackets generally have fallen, resulting in a decline in income tax progressivity. The steady increase in income inequality over the same period has been well documented [e.g., Alvaredo, Atkinson, Piketty and Saez (2013)]. Faced with increasing inequality, some suggest reversing the decrease in marginal tax rates for the highest income levels [e.g., Diamond and Saez (2011)]. At the same time, a literature has emerged to evaluate the optimal degree of progressivity of the tax system [e.g., Heathcote, Storesletten, and Violante (2017)]. What is missing from the literature is an empirical analysis of the business cycle and inequality implications of variations in income tax progressivity. In this paper, we provide a novel measure of progressivity that we then use to undertake such an empirical analysis, using minimal restrictions from economic theory.

A key difficulty in measuring changes in progressivity is that changes in tax legislation typically also affect the level of taxes. Most empirical studies evaluating the economic impact of changes in income taxes have focused on changes to the level of taxes. Typically, these studies identify tax shocks using narrative evidence [e.g., Romer and Romer (2010)], the unexpected changes in the tax revenue series [e.g., Blanchard and Perotti (2002)], or the change in a single effective tax rate that treats agents as homogeneous. While estimates of the magnitude of the tax-level multiplier vary across model assumptions, the general consensus is that increasing the level of taxes is contractionary.

The contribution of this paper is to develop a measure of the progressivity of income tax rates that is orthogonal to the level of taxes to determine how variation in the tax burden affects economic outcomes. We use data on the time-series variation of tax rates on different levels of wage income to quantify both the level and progressivity of taxes. We then estimate a factor-augmented VAR using Bayesian methods, imposing priors from the term structure literature to identify two factors: one that measures changes in the level of taxes and one that measures changes in progressivity.\(^1\) To evaluate the effect of shocks to the tax factors,\(^1\)

\(^1\)While the priors influence the estimated signs and magnitudes of the loadings, they remain loose enough as to not impose the type of exact restrictions found in the literature on the term structure of interest rates [e.g., Diebold and Li (2006)].
macroeconomic variables such as output, consumption, hours, and measures of income and consumption inequality are included in the VAR with the tax factors.

The tax level factor is identified by assuming positive factor loadings for all tax rates. This factor has the effect of raising or lowering tax revenue, and is analogous to the level factor well known in the literature on the term structure of interest rates. The tax progressivity factor is identified by imposing that its loadings are strictly increasing with income. Thus, the progressivity factor will have a similar flavor to the slope factor in term structure models. Based on these identifying restrictions, an increase in progressivity can be interpreted as a counter-clockwise twist in the “term structure of taxes”, where the tax burden on high-income agents increases and the tax burden on low-income agents decreases. Because we identify orthogonal level and progressivity shocks, we can determine the effect of an approximately revenue-neutral shock to tax progressivity on macroeconomic variables, disentangling progressivity shocks from the tax level shocks.

Our two factors account for, on average, over 90 percent of the variation of tax rates for incomes over $20,000. An increase in the level of taxes is contractionary, consistent with a large literature on taxes; on the other hand, an increase in the progressivity of taxes is expansionary. This latter result is novel: We hypothesize that a reduction in taxes on the lower-income workers results in an increase in consumption and output because these workers are credit-constrained and have a high marginal propensity to consume. The increase in taxes on the high-income savers has a smaller effect on actual consumption, and, hence, does not offset on the former rise in economic activity.

We find that progressivity shocks also have distributional effects. Specifically, we find that income inequality rises after an increase in progressivity. That is, we find evidence in favor of “Trickle-Up” effects after a counterclockwise twist in the progressivity of taxes that raises taxes on the highest-wage earners. Although seemingly paradoxical, this result is robust to

\[2\] The result that progressivity is expansionary is consistent with empirical work in Bachmann, Bai, Lee and Zhang (2017), who study the impact of fiscal volatility in a Krusell-Smith (1998) economy with heterogeneous agents and incomplete markets. They use the Castañeda, Díaz-Giménez, and Ríos-Rull (2003) tax function and make the progressivity parameter endogenous. They find that tax progressivity must be procyclical to match the data in the context of the model economy. While this is consistent with our empirical finding, the direction of causality differs between our two papers.
the measure of inequality—either a Gini coefficient or the spreads between income percentiles at the top and middle of the distribution. One way to reconcile these results is that tax changes have both partial and general equilibrium effects. A partial equilibrium effect on impact of the progressivity shock that lowers inequality can be offset by a general equilibrium multiplier response that results in a net increase in income at the high end of the income distribution. We posit that high-income individuals—perhaps because they own the majority of the capital—benefit more from expansions, sufficiently enough that it offsets their higher tax burden. We also investigate the impact on consumption inequality but our results are inconclusive along this dimension.

The literature on tax progressivity is considerably smaller than the literature on overall tax changes. A number of papers have recently emerged to analyze progressivity in the context of quantitative macroeconomic models. The key economic tradeoffs from changes in progressivity are described in Heathcote, Storesletten, and Violante (2017). They emphasize several key channels by which tax progressivity can impact the economy. While a progressive tax system provides insurance against labor market uncertainty, it also induces distortions to labor supply that reduce returns to working and can decrease investment in human capital. A more progressive tax system could then could decrease consumption inequality through the insurance channel while it increases inequality through labor market distortions.

Much of the work in this literature is focused on determining the optimal degree of progressivity in a tax system. For example, Heathcote, Storesletten, and Violante (2017) and Feenberg, Ferriere, and Navarro (2017) both use quantitative heterogenous agent models and conclude that the current level of progressivity in the U.S. is optimal. In constrast, Kindermann and Krueger (2014) find that marginal tax rates as high as 90 percent can be justified. Our work is complementary to this literature, and asks the positive economic question of what will happen after a change in progressivity, rather than the related normative question about how progressive taxes should be.

In related work, Mertens and Montiel Olea (2018; henceforth MMO) study the effect of

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3Feenberg, Ferriere, and Navarro (2017) suggest that, if the labor supply choice is on the extensive margin only, optimal tax progressivity is much larger than in the data.
changes in average marginal tax rates (AMTR) on the macroeconomy. Their approach follows the Romer and Romer narrative approach, but applied to marginal tax rates. Consistent with our level shock results, they find that a decrease in the AMTR for all income levels is expansionary. They then separately identify a shock to the AMTR of the top one percent of the income distribution. They find that a counterfactual tax cut to the top one percent has a positive impact on the incomes of the top one percent, a temporary and positive impact on GDP, and little effect on the incomes of the bottom 99 percent (hence, an increase in inequality). At first glance, the MMO result might seem contrary to what we find. However, their exercise is different than ours in that: (i) we condition on changes to the level of taxes; (ii) we “twist” all tax rates while they shock the tax rate for only a small slice of the income distribution; and (iii) they isolate a few events over the entire sample. This second issue is important as MMO note that changes to the top marginal rate are unlikely to directly generate a large demand stimulus.

The balance of the paper is outlined as follows: Section 2 describes the data used to construct the tax factors, as well as the macroeconomic and inequality data used in the subsequent analysis. Section 3 describes the empirical model, the methods used to estimate it, and the prior used to identify the factor loadings. Section 4 first discusses the results of the estimation using aggregate data. We then present results using measures of inequality that we will use to develop a theory of the propagation of progressivity shocks in the aggregate economy. Section 5 conducts a counterfactual experiment that elucidates how changes in tax legislation manifest as changes in both level and progressivity factors. Section 6 summarizes the results and offers some take aways.

4Their exercise is different than our progressivity experiments in that (i) we also condition on changes in the level of taxes, and (ii) we ‘twist’ all tax rates while they shock the tax rate for only one part of the distribution. This latter difference is important as they note that it is less likely that top marginal rate changes directly generate a large demand stimulus.

5We address the latter issue of the restricted sample in a series of robustness tests in the results section below.
2 Data

2.1 Tax Data

To construct a measure of the distributional incidence of taxes, we need a measure of tax rates as a function of income. Many tax studies use aggregate government revenue, which is a single summary statistic of total tax burden and omits the distributional effect. One possibility is to construct a measure of marginal tax rates by income brackets, which might at first appear to be straightforward. However, using tax brackets by themselves introduces a number of issues. First, the marginal tax rate is not a proper measurement of the final tax bill. Tax legislation often modifies deductions or exemptions rather than simply changing marginal rates. Second, the number of tax brackets and the incomes they are associated with changes over time. Third, the economic and demographic composition of the population can change over time.

Our tax rate data are obtained from the TAXSIM model at the NBER for the years 1974-2015. The TAXSIM program is essentially a tax bill computation program that uses a database of real individual-level tax returns obtained from the IRS to simulate the tax burden of the U.S. federal and state income tax systems. TAXSIM calculates tax liabilities and generates tables of aggregate statistics based on measures of income. These tax rates apply to a hypothetical taxpayer who is married, has two dependents, and no itemized personal deductions. The tax rates are based on an increase in the taxpayer’s wage, for a given current income.

We use the NBER table on U.S. Federal Marginal Income Tax Rates on Wage Income Data where income levels are expressed in real-1992 dollars based on the CPI-U price index. Data are available for tax rates on wage incomes at the following levels: $5,000; $10,000; $20,000; $40,000; $100,000; $200,000; $400,000; and $1,000,000. The data for the first two levels of income are largely constant at 0 or negative numbers in the middle of the sample that make standard time-series analysis difficult. To produce meaningful factors we drop the $5,000 and

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6These data are publicly available at http://users.nber.org/~taxsim/conrate/. The full dataset is available from 1960-2016. We use only data from 1974-2015 in order to match data availability for the inequality measures described in Section 2.4.
$10,000 levels and thus are left with tax rates for six income levels to estimate the factors.

The TAXSIM data does not solve all of the issues associated with the use of tax brackets that we raised above. While the TAXSIM data does incorporate the EIC and standardized deductions for some dates, personalized deductions are omitted. Thus, the deductions associated with the mortgage interest would also be omitted.

2.2 Tax Factors

The TAXSIM data contains time-series information on tax rates for a range of income levels. Our ultimate interest is in identifying tax shocks in a VAR and measuring the impact on macroeconomic variables and the distribution of income and consumption. To do so, we summarize movements in the tax data by identifying two different effects from the tax data. First, we consider the overall level of taxes, similar to the exogenous shock in previous studies [e.g., Blanchard and Perotti (2002); Romer and Romer (2010)]. This level reflects the overall burden of taxes, where a rising level of taxes is a contractionary fiscal shock.

Second, we consider the progressivity of taxes, which determines how the tax burden is distributed across income levels. In this case, an increase in tax progressivity manifests as an increase in the taxes paid by higher income levels and a decrease in taxes paid by lower income levels. It is important to note that our interpretation of tax progressivity implies a shift in the tax burden across income levels at (approximately) a constant level of taxes. That is, an increase in progressivity is associated with both an increase in taxes on high incomes and a decrease in taxes on lower incomes but is orthogonal to changes in the level of taxes.

We model changes to the tax code similarly to how one would model changes in the term structure of interest rates, thereby reducing the dimensionality of the tax-rate data by summarizing their movements into two latent factors. As a first pass, we compute the first and second principal components of the “term structure of taxes” using the annual data for the tax brackets to determine the level and progressivity.

Figure 1: Tax Principal Components
The two principal components are plotted in Figure 1. Our tax factors are comparable to the tax series found in other studies. For example, the correlation between the difference of the tax level principal component and the Romers’ tax shock series (for dates in which the series overlap, 1974-2007) is 0.41. The progressivity factor is consistent with narrative evidence as it shows a sharp decline in the late 1980s followed by a steady increase. Although we find progressivity in the pre-1980s period is higher, the decline and steady increase we find is consistent with Feenberg, Ferriere, and Navarro (2017).

How well do these factors represent actual fluctuations in the tax rates? Table 1 shows the shares of the variance of each tax bracket explained by the two tax factors. Taken together, the level and progressivity factors explain, on average, over 90 percent of the tax data for brackets above $20,000. These results suggest that our factor approach provides a parsimonious yet comprehensive characterization of movements in taxes.

Movements in these principal components can also be associated with historical policy changes. For example, in the early 1980’s, the Kemp-Roth Tax Cut called for an across-the-board decline in marginal tax rates in an effort to boost the economy. This tax cut manifests more in a gradual decline in the overall level of taxes—the first factor, but a less substantial change in progressivity. On the other hand, the Reagan Tax Reform Act of 1986, which was meant to simplify the tax code and eliminated a large number of tax brackets, led to a substantial decline in both factors. The Omnibus Budget Reconciliation Act of 1990 increased the top marginal tax rate from 28 percent to 31 percent, reformed capital gains taxes, and limited high-valued itemized deductions. Subsequent to this legislation, the level of taxes do not change substantially but progressivity rises steadily over the sample period.

These historical episodes highlight the importance of modeling both changes in the level of taxes and changes in the progressivity of taxes. While each piece of legislation affected the level of taxes, without simultaneously modeling tax progressivity, the total impact of the change in the tax law may be misinterpreted, if not mismeasured.

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Feenberg, Ferriere, and Navarro (2017) construct progressivity based on a nonlinear tax function based on Feldstein (1969), \( \tau(y) = 1 - \gamma y^{-\gamma} \), where \( \tau(y) \) is the tax rate on the level of income \( y \). The parameter \( \gamma \) in their scheme represents tax progressivity.
2.3 Macro Data

In order to estimate the effects of the tax factors, we utilize a variety of macroeconomic data. In order to remain consistent with the tax data, all macro data are annual. The baseline case includes the log of real GDP. To further identify the channels through which progressivity shocks can influence the aggregate economy, we augment the baseline VAR iteratively with either the log of real personal consumption or the log of total aggregate hours for nonfarm payrolls divided by the population 16 years and over. When including consumption data, we opt to remove GDP from the VAR due to issues with collinearity. This is not a problem with hours data and, thus, the VAR with this labor market measure includes all four variables. To match the data availability for our subsequent exercises with income and inequality data, we use data from 1974-2015.

2.4 Inequality Data

We use the recently developed data by Piketty, Saez and Zucman (2018) to measure income inequality. They combine tax and survey data to create a comprehensive estimate of income inequality. Some alternatives would be to just use the individual-level data from the March Supplement of the Current Population Survey (CPS), or data based on IRS tax returns. The choice of which datasets should be used to measure income inequality has been met with some controversy. In particular, Atkinson, Piketty and Saez (2011, APS) claim that the CPS data understates the rise in the top 1-percent of income. Instead, APS use data obtained from tax returns to measure the income distribution. The CPS data has an advantage over tax-based data in that it covers the full range of incomes. Tax data does not cover the bottom end of the income distribution, as tax is typically not paid on these incomes. The new measure combines both tax and survey data, and hence is more accurate than CPS data, yet retains a comprehensive coverage of the entire distribution with the CPS data.

The empirical facts about changes in consumption inequality are much less established than those about income inequality. Different surveys yield a somewhat different conclusion about the pattern of consumption inequality over the time. The Panel Study of Income
Dynamics (PSID) data used in Attanasio and Pistaferri (2014) shows rising consumption inequality. The Interview survey of the Consumer Expenditure Survey used in Heathcote, Perri, and Violante (2010) shows that consumption inequality has not been rising. However, computing consumption as the difference between disposable income and active savings using the same Consumer Expenditure Survey data, Aguiar and Bils (2015) find rising consumption inequality.

We adopt the recent consumption inequality measure from Fisher, Johnson, and Smeeding (2013). Their measure of consumption is broad and includes both disposable consumption and an estimated service flow for housing and vehicle purchases. They find that consumption inequality has risen roughly the same as income inequality. We take no stand on which measure is most accurate, the advantage for our work is that the Fisher, Johnson, and Smeeding (2013) sample period (1985-2010) is most similar to ours.

3 Empirical Approach

While our tax level factor appears correlated with existing measures of taxes, we want to ensure that the interpretation for our tax level series is consistent with the previous literature on taxes. More importantly, we want to determine how our new tax progressivity shocks impact the national economy. To do this, we consider three standard aggregate-level VARs: the first includes only real output and the tax shocks, the second replaces output with consumption data, and the third augments the VAR with the employment data.

While we have previously described the tax factors produced by principal components, we now re-estimate the factors in a state-space framework using the Kalman filter to generate the factors. Estimating a parametric alternative for the factors will allow us to impose restrictions on the factor loadings that will provide a clearer interpretation of the factors. That is, we will produce more structurally-interpretable factors. In the term-structure literature, factors are often generated by methods that restrict the loadings on the factors—see, for example,

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8 A caveat to this measure is that the PSID is limited in the amount of expenditure collected.
9 Results for all measures of consumption inequality are available by request.
Nelson and Siegel (1987). In that paper, the level factor is estimated assuming coefficients on the factor are all unitary. The yield curve then rises equally across all maturities with movements in this factor. The slope factor imposes rising coefficients across maturities, with a free parameter to govern the slope. Movements in the slope factor then have heterogeneous effects on yields. Their approach does not impose orthogonality in the two factors as would be imposed in principal components. The state-space framework will allow us to parameterize a prior that puts ex ante weight on a zero correlation between the two factors as in the principal components approach while allowing priors to push the loadings towards those in the term-structure literature.

3.1 Model

Let $R_t = [R_{1t}, ..., R_{Kt}]'$ be the $(K \times 1)$ vector of tax rates. Define $\tau_t$ as the period–$t$ value of the (latent) tax level factor and $\mu_t$ as the period–$t$ value of the (latent) progressivity factor. The latent factors are related to the tax rates via

$$
\begin{bmatrix}
R_{1t} \\
R_{2t} \\
\vdots \\
R_{Kt}
\end{bmatrix} = 
\begin{bmatrix}
\rho_1 \\
\rho_2 \\
\vdots \\
\rho_K
\end{bmatrix}
+ 
\begin{bmatrix}
\lambda_1^\tau & \lambda_1^\mu \\
\lambda_2^\tau & \lambda_2^\mu \\
\vdots & \vdots \\
\lambda_K^\tau & \lambda_K^\mu
\end{bmatrix}
\begin{bmatrix}
\tau_t \\
\mu_t
\end{bmatrix} + 
\begin{bmatrix}
u_{1t} \\
\mu_{2t} \\
\vdots \\
\mu_{Kt}
\end{bmatrix},
$$

(1)

where the $\rho_k$ are scalar intercepts, $u_t = [u_{1t}, ..., u_{Kt}]'$ and $E[u_t' u_t'] = \text{diag} [\sigma_1^2, ..., \sigma_K^2]$ assumes that the only correlation in the tax rates arises from the factors. The $\lambda_k^\tau$ and $\lambda_k^\mu$ are factor loadings that determine the effects of fluctuations in the factors on the tax rates. An approximation of the Nelson-Siegel would be $\lambda_k^\tau = 1$ for all $k$, $\lambda_k^\mu > \lambda_k^\mu$ for all $k = 1, ..., K - 1$. An approximation of principal components would be $\lambda_k^\tau \simeq 1$ for all $k$, but would not strictly hold to 1, and the upper block of the variance-covariance matrix of the state equation would be diagonal.

Let $X_t$ represent the $(N \times 1)$ vector of variables of interest and define $Y_t = [\tau_t, \mu_t, X_t]'$. Then, the specification of the aggregate-level structural VAR is standard:
\[ A_0 Y_t = A(L) Y_{t-1} + e_t, \quad (2) \]

where \( A_0 \) is the matrix of contemporaneous effects, \( A(L) \) is a matrix polynomial in the lag operator, and \( e_t \sim N(0, I) \) are the structural shocks. To facilitate exposition, we can rewrite (2) as

\[
\begin{bmatrix}
\tau_t \\
\mu_t \\
X_t
\end{bmatrix}
= 
\begin{bmatrix}
A_{\tau\tau} (L) & A_{\tau\mu} (L) & A_{\tau x} (L) \\
A_{\mu\tau} (L) & A_{\mu\mu} (L) & A_{\mu x} (L) \\
A_{x\tau} (L) & A_{x\mu} (L) & A_{xx} (L)
\end{bmatrix}
\begin{bmatrix}
\tau_{t-1} \\
\mu_{t-1} \\
X_{t-1}
\end{bmatrix}
+ 
\begin{bmatrix}
e_{t} \\
e_{t}^\mu
\end{bmatrix},
\]

which isolates the effects of lags of variable \( j \) on variable \( i \) in each lag polynomial, \( A_{ij} (L) \).

The VAR is estimated in the reduced form:

\[ Y_t = B(L) Y_{t-1} + \varepsilon_t, \quad (3) \]

where \( B(L) = A_0^{-1} A(L) \), \( \varepsilon_t \sim N(0, \Omega) \) are the reduced-form shocks, and \( \Omega = A_0^{-1} A_0^{-1'} \) is the reduced-form variance-covariance matrix. The structural form is obtained from the reduced form by imposing some identifying restrictions on the contemporaneous effects of the shocks on certain variables. We discuss the identification assumption below.

### 3.2 Inference

We estimate the FAVAR described in the previous section at the annual frequency with two lags using Bayesian techniques, which allow us to impose a prior on the factor loadings to interpret the factors. The form of the prior we impose is relatively standard. For the VAR, we assume a normal prior on the lag polynomial and an inverse-Wishart prior on the reduced-form variance-covariance matrix. The \( \rho_k \) are obtained by ex ante demeaning the tax series and do not require a prior; similarly, we demean the macro variables in the VAR. The variances of the tax rates are inverse gamma priors and assumed to be independent and the factor loadings are normal priors. The prior parameters are shown in Table 2.
It is straightforward to estimate the FAVAR with a Gibbs sampler. The sampler is a Markov-chain Monte Carlo technique. Given an initial draw of the set of parameters, including the factors, we sequentially draw from blocks of parameters, conditional on the current draw of the other parameters and the data. After allowing for a suitable number of draws to allow the algorithm to converge, draws from the conditional distributions reflect draws from the joint posterior density. For our sampler, we have three blocks: (1) the VAR parameters, (2) the measurement equation parameters, and (3) the factors. Draws from the first block are conjugate normal-inverse-Wishart. Draws from the second block are conjugate normal-inverse-gamma. The factors are drawn from the Kalman filter and smoother, conditional on the model parameters with the additional identifying restriction that the loadings on the first factor are positive and the loadings for the second factor are increasing across the income levels.

3.3 Identification

We identify the structural form of the VAR by imposing ordering restrictions, and obtaining the contemporaneous effects matrix via the Cholesky decomposition. Consistent with the existing literature, we order the tax shocks first in the VAR, followed by the macro variables. We order the tax-level shock ahead of the progressivity shock. It is not necessary for us to impose an ordering for the subset of macro variables; however, we impose an ordering consistent with previous papers such as Romer and Romer.

Cholesky identification imposes an exact identification of all the model shocks. Thus, we exactly identify both the level and progressivity shocks. As we implied above and will discuss in detail later, most tax legislation will be represented by a combination of both level and progressivity shocks. In this sense, our identification is similar to Inoue and Rossi (2019), who estimate a “functional VAR” to measure the effects of monetary policy. Inoue and Rossi identify composite shocks to the level, slope, and term structure of interest rates by examining the evolution of the parameters in Nelson-Siegel regressions.\(^\text{10}\)

\(^{10}\)The analogous functional VAR to our approach would be to estimate a parametric tax function such as the one proposed by Feldstein (1969), where \(\tau(Y) = 1 - \lambda Y^{-\gamma}\). One would then estimate the VAR with the
4 Aggregate Results

Before we examine how shocks to the two tax series affect aggregate economic variables such as income, consumption, and hours, we compare the factors from the FAVAR with the factors using principal components. One drawback of estimating the factors parametrically in the state-space model is that they become model-dependent—that is, changing the variables in the VAR may alter the estimates of the factors. However, we prefer the structure of the FAVAR, as it allows the identification of shocks. Fortunately, the time series for the factors estimated in the state space are highly correlated with the factors estimated using principal components. Figure 1 compares the two sets of factors, one estimated with principal components and the other estimated parametrically in the state space. The correlation of the level factor estimated in the state space and the level factor estimated from principal components is 0.99 and the correlation of the progressivity factors is 0.84.

4.1 The Effect of Tax Shocks on Tax Rates

We now consider the static effect of the unit change in the two tax factors on the tax rates for each income level as reflected in the factor loadings. From equation (1), we can obtain the average change in the tax rates at the time of a change in either the level or progressivity. The loading determines the contemporaneous effect of a unit change in corresponding the tax factor. Figure 2 plots the factor loadings for the two estimated tax factors as a function of income. Two results are immediately apparent.

First, the loadings on the tax level factor are all positive—ranging between 0.8 and 1.8 and averaging 1.3—but are not equal across income levels nor are they monotonically increasing. A unit shock to the tax-level factor results in an increase in the tax rate of about 0.8 percentage points at $40,000 but 1.4 percentage points at $100,000. Thus, an increase in the tax-level factor will produce an across-the-board increase in the tax rates; however, the magnitude of the time series of λ and γ, imposing that λ and γ are unrelated at lags.
the shift is still not exactly equally-distributed across all income levels.\textsuperscript{11}

Second, the loadings on the progressivity factor are negative for low incomes and positive for higher incomes. Thus, an increase in the progressivity factor shifts the tax burden unequally across income brackets. In particular, the twist in the tax term structure places increased tax burden only on the top three rates, with only a small increase in the lowest of these three top rates. This result is not surprising given that our prior also has increasing means across incomes. However, the point values of the posteriors can differ substantially from the prior mean; for example, the prior mean at $100,000 is 0 but the posterior mean is $2.

### 4.2 Macroeconomic Outcomes

Figure 3 Impulse Responses

Having determined how shocks to the tax factors affect the tax rates, we now turn to evaluating the effect of the tax shocks on some macroeconomic outcomes. To do this, we compute the impulse responses of the macro variables to the two tax shocks, identified by the Cholesky scheme described above.

The six panels of Figure 3 plot the impulse responses to tax level (left column) and progressivity (right column) shocks. The responses of output (top panel), consumption (center panel), and hours (bottom panel) are obtained from separate aggregate-level VARs for the sample 1974 to 2015. As mentioned previously, we remove output from the VAR with consumption to avoid issues with collinearity. Alternatively, we add hours to the baseline VAR with output and thus estimate a four-variable VAR. Qualitatively consistent with the existing literature, the tax level shock is contractionary. Perhaps the more interesting result is shown in the left column of Figure 3, where we report the effects of an increase in progressivity. Keeping in mind that the progressivity shock controls for the level of taxes, an increase in progressivity—shifting the tax burden from the relatively poor to the relatively rich—raises output over a 5-year horizon. That is, increasing the progressivity of taxes results in an increase in

\textsuperscript{11} As a robustness check, we estimated a model in which the loadings on the level factor were restricted to be equal across incomes. The resulting progressivity factor was qualitatively similar.
economic boom: Output, consumption and hours worked all rise.

The expansionary effect of (locally) increasing in progressivity is a striking result. Thus, it is important to verify robustness of this result to alternative identification schemes, as there are competing views on how to best identify a structural shock. For example, in the monetary literature, Coibion (2012) investigates the reasons for differences between Romer and Romer (2010) monetary shocks and monetary shocks identified with the Cholesky decomposition. In the spirit of that exercise, we construct a set of alternative progressivity shocks from our progressivity series but using only the observations occurring on the Mertens and Montiel Olea (2018) dates. In this sense, we “filter” our full sample shocks and employ only the exogenous events that they consider. Figure 4 shows the result of this exercise. From the results shown in the top row, it is clear that results from the unfiltered sample and the results using only the Mertens and Montiel Olea dates are qualitatively similar, although there are some differences in magnitudes. Importantly, in the second row the response of GDP to each shock is consistent with our benchmark results.

Figure 4: Benchmark and Purely Exogenous Impulse Response Functions

4.3 Why Is a Progressivity Shock Expansionary?

The rise in income after an increase in progressivity is a new empirical result that is uncovered by our methodology for measuring tax progressivity shocks. The result is consistent with papers that find heterogeneous responses of consumption to changes in income [e.g., McCarthy (1995); Dynan, Skinner, and Zeldes (2004); Jappelli and Pistaferri (2010); and Parker, Souleles, Johnson, and McClelland (2013)]. Further, Gruber and Saez (2002) find

\[ A_{\tau\alpha} (L) = A_{\tau\tau} (L) = A_{x\tau} (L) = A_{x\alpha} (L) = 0. \]

Our results are qualitatively similar in that increasing the tax level is contractionary and increasing progressivity is expansionary. In general, the contractionary effects of level shocks tend to be larger under these restrictions and the expansionary effects of progressivity shocks take longer to kick in. These results are available from the authors upon request.

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12 They include fifteen events in their sample from 1946-2012, with eleven of their events occurring in our sample period of 1974-2015.

13 We find that the tax level factor falls following an increase to progressivity. In order to ensure that this reduction in level is not responsible for the subsequent economic boom that observe, we also estimate a version of the VAR in which the factor dynamics are restricted such that each factor depends only on its own lags. Thus, we restrict the VAR coefficients such that: }
that, because high earners can itemize deductions, the elasticity of taxable income varies across the income spectrum. In particular, agents at the low end of the income distribution are credit-constrained and wish to consume more. As their tax rates fall, assuming that their marginal propensity to consume is near one, they increase their consumption nearly dollar-for-dollar. Those at the higher end of the income distribution have lower marginal propensities to consume and do not reduce their consumption as tax rates rise. Additionally, changes to marginal tax rates for the wealthy appear to have little impact on work effort.\textsuperscript{14} The net effect is an expansion in consumption that results in an economic boom. The expansion leads to an increase in aggregate hours worked as well as hours typically rise in an expansion.

Figure 5 Income Inequality IRFs

Intuitively, the nature of the progressivity-induced expansion should lower inequality, as disposable income rises for low-wage earners and falls for high-wage earners. Paradoxically, we find that income inequality rises after the progressivity shock (see Figure 5). This increase in income inequality, however, does not necessarily imply that those at the lower end of the distribution are less well-off in terms of welfare: The expansion increase their income and consumption, but the income of those at the top end of the distribution increases more.\textsuperscript{15} The progressivity-induced boom then raises income for all but more so at the top end. In the three income measures depicted in Figure 5, we see a strong response in the changes of the 99-50 and 95-50 percentiles: Those at the top gain much more than those in the middle during the expansion. Moving further down the distribution, the change for the 90-10 percentile is smaller and not significant, suggesting that the increased Gini is driven by the large gains of the upper tail.

Tickle-down econonomics suggests that lowering tax rates on those with high incomes spurs an expansion. To the contrary, our empirical results suggest that the opposite is true:

\textsuperscript{14}See, for example, Zidar (2019), who considers income heterogeneity by location and finds that tax cuts for the top 10\% have very small effects on employment growth in that demographic.

\textsuperscript{15}This result is consistent with empirical evidence that the economy disproportionately rewards those at the top end of the distribution in a “winner-take-all” type environment. It is also consistent with stagnant wages in the middle of the income distribution, which has occured even in expansions.
Lowering the tax burden on lower incomes sets off an expansion that also raises the incomes of those at the high end of the income distribution. This is consistent with trickle-up—not trickle-down—economics.

Figure 6 Consumption Inequality IRFs

It is ambiguous what should happen to consumption inequality after the progressivity shock. On the one hand, the boom is set off by increased consumption at the low end of the distribution. On the other hand, the nature of trickle-up economics is such that the rich end up with even greater income gains. The net impact then is unclear in theory. In Figure 6, we can see that the response of consumption inequality to the progressivity shock is to rise slightly on impact but then is essentially zero. That is, we do not find that consumption inequality mirrors the response of income inequality in response to the progressivity shock. Note that there are mixed results in the literature on consumption inequality, where it is not clear if consumption inequality is rising or falling over time.

To summarize, we find that increasing (locally) the progressivity of taxes raises GDP growth and, simultaneously, increases income inequality and, weakly, increases consumption inequality. We have previously hypothesized that a shock to progressivity acts initially through the consumption channel. Initially, an increase in tax progressivity increases disposable income for low-income agents and lowers disposable income for high-income agents. This, in turn, raises consumption at the low end of the income distribution and lowers consumption at the high end of the income distribution. To generate a net increase in aggregate income, consumers at the low end of the income distribution spend all or most of their newfound income, while consumers at the high end of the income distribution reduce their consumption by only a (perhaps small) portion of the decrease in disposable income. This result contrasts with Kindermann and Krueger (2014), who find that aggregate consumption falls with a rise in the highest marginal tax rate, which is all due to a sharp decline in consumption of high-income earners. However, as they note in their paper, their results depend on assumptions about the labor productivity process and elasticities. Here, we provide a set of empirical facts
independent of such assumptions.

Note that the standard story on the transmission via the tax multiplier does not lead to an increase in income inequality. In the single (type) agent model, a shock to the tax rate that increases disposable income generates a multiplier effect in which the increase in consumption is repeatedly redistributed back to the agents. In the heterogeneous-income environment, if this multiplier income is proportionately redistributed across both high- and low-income agents, the Gini does not change. Thus, we need to describe an alternative transmission mechanism for the multiplier in our environment.\textsuperscript{16} To achieve the increase in income and consumption inequality that we observe, the revenue from the new consumption must not be equally spread over the income distribution.\textsuperscript{17}

This could occur if, for example, low-income agents are fixed-wage laborers and high-income agents own the capital stock. Moreover, assume that that number of low-income agents outnumbers the number of high-income capital holders. The initial impact of the progressivity shock raises (lowers) disposable income of the low (high) income agents, with the net effect being expansionary. The multiplier effect, however, is not spread equally across agents, with low-income agents benefitting only from the initial shock and not from the multiplier effect. Therefore, even though the initial shock lowers the disposable income of high-income agents, the net effect on these agents is positive via the multiplier effect. The size of the multiplier effect will depend on both the concentration of wealth and the degree of market power of the capital owners. We take no stand on the size of these, rather, our empirical results rely on minimal theoretical assumptions.

On the labor side, we find (aggregate) hours worked expanded with an increase in progressivity. In theory, increasing high marginal tax rates should decrease the labor supply of high-income workers and decreasing lower marginal tax rates should increase hours worked at the low end of the distribution. However, the empirical literature has found that high-income earners adjust their tax avoidance behavior when faced with tax changes [e.g. Slemrod (1996)],

\textsuperscript{16}Moreover, a lump-sum–type redistribution would lower the Gini, as it would raise the lower-income agents’ incomes proportionally more.

\textsuperscript{17}Moreover, if high-income agents save proportionally more than low-income agents, they also must see a disproportionate increase in income.
not their labor supply. As Slemrod (1996) argues, “A number of studies have shown large
and quick responses of reported incomes along the tax-avoidance margin at the top of the
distribution, but no compelling study to date has shown substantial responses along the real-
economic margin among top earners.” Our boom in hours is then likely the result of increased
hours worked at the low end of the distribution and no or little response at the high end of
the income distribution.

5 Raising Marginal Tax Rates: An Experiment

In the previous sections, we showed that increasing the level of taxes is contractionary while
increasing the progressivity of taxes is expansionary. As Figure 2 suggests, most of the
tax policies enacted over the sample period are a combination of shocks to both level and
progressivity. For example, we highlighted earlier that the Reagan Tax Reform Act of 1986
resulted in a decline in both factors. While the effect of the structural level and progressivity
shocks can be evaluated in isolation in the VAR, the mapping between a real-world tax policy
and the change in the level and progressivity shocks occurs in the measurement equation of
the factor model. Thus, to determine the net effect of tax policies that are comprised of both
a level and progressivity shock, we must evaluate how a particular policy maps into the two
factors. Here, we consider two examples of tax policies, both of which would be considered
contractionary increases in taxes in an environment in which the tax level were the only policy
instrument. We describe how the changes in legislation map into the factors and evaluate their
net effects.

At time $T$, the update step of the Kalman filter determines the magnitude of the change
in the mean of the posterior distribution of the state vector. Thus, the effect of changing any
part of the tax vector, $R_T$, on $F_T$ would be proportional to the Kalman gain, $G_T$:

$$\Delta F_T = G_T^* \Delta R_T,$$

where $G_T^*$ represents the first two rows of the Kalman gain matrix. Note that this decomposi-
tion imposes that the largest percentage of the variance of $R_T$ is explained by the factors. The balance of the variance is remanded to the innovation in the measurement equation, which we assume does not propagate through the VAR and, thus, does not affect output.

Our first experiment considers proposed tax legislation that increases the tax rate on the top of the income distribution by 10 percentage points. In our model, this tax legislation is represented by an increase in $R_{KT}$, where $K = \$1$ million and $T$ is the time at which the tax increase is levied. Specifically, the proposed tax legislation can be modeled as

$$\Delta R_T = \begin{bmatrix} 0'_{((K-1) \times 1)} & \Delta R_{KT} \end{bmatrix},$$

where $\Delta R_{KT} = 0.1$. Given this counterfactual change in the tax code, we can compute the effect on the factors.

**Figure 7 Experiment 1/2**

Based on the means of the posterior distribution of the model parameters, the proposed tax legislation results in a change in the factors of $\Delta F_{1T} = -0.043$ and $\Delta F_{2T} = 0.012$. Thus, the proposed legislation acts to shift down the level of taxes but increase the progressivity. Given these changes in the factors, we can compute the net effect of the tax legislation by assuming that $\Delta F_T$ embodies a reduced-form shock. The top row of Figure 7 show the effect of the composite shocks. The left panel shows the impulse response of output to a level shock of the appropriate size; the center panel shows the impulse response of output to a progressivity shock of the appropriate size; and the right panel shows the net effect, represented by the sum of the two components. Both a decrease in the level of taxes and an increase in tax progressivity are expansionary. Thus, the long-run net effect of the legislation shown in the rightmost panel is unambiguously expansionary in our framework. In a model in which the tax level were the only instrument, the legislation would be an increase in the tax level and, thus, unambiguously contractionary.
Figure 8 Graphical Depiction of the Experiments

What leads to the difference in the outcomes across the two models? While the model with just the level shock can only produce the proposed legislation with a contractionary increase in taxes, the left panel of Figure 8 shows how this legislation manifests in our environment. Each of the tax rates are the sum of a tax level component and a tax progressivity component. The increase in the highest tax rate leads to a counterclockwise rotation in the distribution of taxes—an increase in tax progressivity. The increase in tax progressivity alone would increase the expected tax rates at incomes just below $1 million (i.e. $200k and $400k). Thus, to compensate for the increase in these rates caused by the increase in progressivity, the tax level decreases.

We next consider a 10-percentage-point increase in each of the top two tax rates (at $400k and $1M income). This legislation produces both an increase in the level of taxes and the progressivity of taxes. The right panel of Figure 8 shows why this legislation produces an increase in the level of taxes. To capture the rise in the top two rates, progressivity increases even more than in the previous counterfactual. The expected rates at lowest incomes are now too low and the tax level must shift up to account for this.

Because one effect is contractionary and one effect is expansionary, we need to compute the net effect to determine whether the sign of response is positive or negative. The bottom row of Figure 7 shows the effect of each shock and the combined effect (right panel). Here, the level effect dominates the progressivity effect and produces a net negative effect on output in the long run.

6 Summary and Conclusion

The objective of this paper has been to develop empirical facts related to changes in the progressivity of taxes. To do so we developed a new measure of progressivity that conditions on changes in the level of taxes. The impact of our tax level factor is consistent with the existing
tax literature and most economic theory. Our progressivity factor yields novel empirical insights. In particular, we find evidence in favor of trickle-up economics. After an increase in progressivity, an economic boom is set off. Paradoxically, the boom does not lower income inequality because those in the upper tail of the distribution benefit more from economic booms. We do not interpret this as a negative result, rather it suggests that other, non-income-tax-based policies would need to be enacted to reduce inequality.

A key message of the paper in evaluating policy is that because taxes are levied on people differently and there is heterogeneity based along the income dimension in the response to taxes, one needs to evaluate the effect of any tax legislation by considering both the level of taxes and the degree of progressivity. In models where only the level shock is available, some legislation would be considered contractionary. In an environment where both level and progressivity are relevant, the effect of the same legislation might be ambiguous until one examines the relative changes in both level and progressivity.
References


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Table 1: Variance decompositions computed based on the tax level and progressivity factors produced from the FAVAR model
Table 2: Priors for the Model Parameters

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Table 2: Priors for the Model Parameters: $N$ is the number of variables in the VAR and $m$ is the number of parameters for each lag of the VAR

Figure 1: First two principal components from observed tax data
Figure 2: Factor loadings estimated from FAVAR model

Figure 3: Impulse responses from the FAVAR with (i) the tax level factor, tax progressivity factor, and log real GDP; (ii) the tax level factor, tax progressivity factor, and log real consumption expenditure; and (iii) the tax level factor, tax progressivity factor, log real GDP, and log hours/population.
Figure 4: Impulse responses from the FAVAR with (i) the tax level factor, tax progressivity factor, and log real GDP; (ii) the tax level factor, tax progressivity factor dummied out to include only the dates identified by the narrative approach in Mertens and Montiel Olea (2018), and log real GDP.

Figure 5: Impulse responses from the FAVAR with the tax level factor, tax progressivity factor, log real GDP, and various measures of income inequality from Piketty, Saez and Zucman (2018).
Figure 6: Impulse responses from the FAVAR with the tax level factor, tax progressivity factor, log real GDP, and a measure of consumption inequality from Fisher, Johnson, and Smeeding (2013).

Figure 7: Impulse responses from the two policy experiments. In Experiment 1, the tax rate on the highest incomes, over $1 million, is increased by 0.1. In Experiment 2, the tax rate on the two highest incomes, over $400,000 and over $1 million, are increased by 0.1.
Figure 8: Graphical representation of the policy experiments and the effects on the tax level and progressivity factors. The left panel shows Experiment 1 in which the tax rate on the highest incomes, over $1 million, is increased by 0.1. The right panel shows Experiment 2 in which the tax rate on the two highest incomes, over $400,000 and over $1 million, are increased by 0.1.