Flooding Times:
Tax Cuts and Stock Market (In)stability

Pau Belda-i-Tortosa*

January 2019

Abstract

What is the effect of tax cuts on the stock market volatility? The hypothesis we explore is that taxes play an important role on it. First, we collect 6 facts that points out the world-wide top tax cuts, the strong negative correlation between them and the PD ratio and the dynamic interdependence between top taxes and the PD ratio. Second, to build a causal understanding of that facts, we present a consumption-based asset-pricing model with taxes. It is an extension of the well-behaved Adam, Marcet & Nicolini (2016) model that introduces taxes in the budget constraint and in the expectation formation process. The model is well-behaved in terms of i) relative volatility and persistence of the PD ratio and ii) dynamic responses of the PD ratio to tax shocks, but it overstates the effects of tax shocks.

Keywords: Tax Cuts, Stock Market Volatility, Asset-Pricing, Internal Rationality.

Profits are like the gasoline of the capitalist automobile:
without them the car stops, but it also stops if there are too many
because then the engine is flooded.

P. Sylos Labini (2005)

IN THIS TERM PAPER, we explore the relation between taxation and stock market stability. The hypothesis we raise is that tax shocks drive (part of) the volatility of the PD ratio. They do so through a standard channel: increasing the investor' available resources (income effect) and making stocks relatively more profitable (substitution effect). But also through a non-orthodox

*2nd year student at the International Doctorate in Economic Analysis (IDEA), Universitat Autònoma de Barcelona (UAB), Barcelona Graduate School of Economics (BGSE). This is a term paper for the "Expectations and Optimal Policy" course, taught by Albert Marcet during the Fall of 2018. Email: pau.beldaitortosa@gmail.com.

one: changes on taxes impact on the process of expectation formation, boosting up further the demand and yielding higher prices, in a sort of self-fulfilling prophecy.

This prior finds backing in real-world data. We present new exploratory evidence about the relation between tax cuts and the PD ratio for 6 countries (U.S., U.K, France, Italy, Netherlands and Sweden) that highlights the strong negative tax-PD correlation and its intertemporal relations. With these evidence in mind, we study the causal relation between taxes and stock market stability using a variant of the Adam, Marcet and Nicolini (AMN from now on) (2016) model. It is a conventional consumption-based asset pricing model with time-separable preferences and internal rationality. The use of this model is legitimated by the fact that it succeed in replicating many of the stylized facts that the standard asset pricing model à la Lucas (1978) with time-separable preferences and RE did not. The key mechanism it stressed is the self-referential process between risk-adjusted capital gains expectations and the realizations of these risk-adjusted capital gains. Keeping this basic feature, we extend it to incorporate the role of top taxes through both the budget channel and the expectations one. The model perform reasonable well in terms of volatility, persistence and dynamic responses.

The term paper is organized as follows. Section 1 presents a data analysis exercise that summarize to 6 facts about the top marginal income tax rate and the PD ratio. These facts act as a landmark for both thinking and assessing the model. Section 2 briefly reviews what we know about the effects of tax cuts, pointing out a hole: there are very few works about the effect of tax cuts on the stock market instability. In section 3 we present the model and derive some analytical results. Section 4 calibrates the model with US tax data and compare the simulated with the real PD ratio. It concludes that the model does well in some dimensions, but overestimates the response of the PD ratio to a tax shock. Finally, section 5 closes the document by setting out a list of shortcomings that must be addressed by future research.

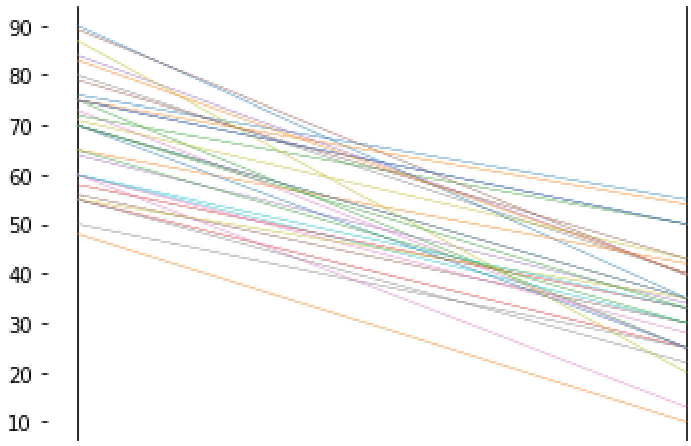
1 Tentative Facts

This section mines some tentative facts from real-world data in order to gain better understanding of the processes going on and to discipline the model with a set of outcomes that it should replicate. There has been two particular periods that concentrated the biggest tax cuts, the 1920s and the 1980/90s. Two big episodes happened in the 20s: U.S. dropped its top marginal income tax rate from 73% in 1920 to 24% in 1929; France from 72% in 1924 to 30% in 1927. This episode was a prelude of the world-wide tax cut occurred during the 80s and 90s. Graph 1 pictures the top marginal income tax rate before and after the tax cuts came (1979 and 1990/2002) [1]. It evidences the wide geographic scope and the negative slope of the tax line; before the cuts, the top tax ranged

[1] The Data Appendix contain the information about the countries in the sample and the time period for each of them.

from 90% to 50% whereas it ranges from 55% to 10% after them. In other words, the minimum before was almost the maximum after. The cross-country average decreased from 69% to 34%. This huge and world-wide top marginal income tax cut is reported as the Fact 1.

Figure 1: Top marginal income tax rate cuts across the world (1979-1990/2002).



One of the potential consequences of tax cuts is an increase in the volatility of the stock market. Some data legitimates this prior. We built a quarterly time-series panel of 7 countries (U.S., U.K., France, Italy, Germany[2], Netherlands and Sweden) for the top marginal income tax rate and the Price-Dividend ratio from 1975 to 1995. Additionally, we have very long-run data for taxes and the PD ratio for 3 countries (U.S., U.K. and France), that covers the 1920s tax cut[3]. Descriptive statistics report a second fact: there is a strong negative correlation between the levels of the PD and the top marginal income tax rate. The average correlation is -0.5 (including episodes in the 20s and in the 1975-95; it is -0.55 if we account only for 1975-95 period). Thus, in average 25% of the variation of the PD ratio can be explained by the variation of the top income tax. Notice that this correlation is equally high for countries that implement a steeper tax cut (such as the U.K.) as for countries with moderate tax cuts (only 10pp as Netherlands). Additionally, the higher the volatility in the taxes, the higher the volatility of the PD ratio (i.e., positive correlation between standard deviations; in average is equal to 0.26). This is Fact 3.

The hypothesis we raise is dynamic: tax cuts impact over today and tomorrow stock market

[2]We have only annual data for the German PD ratio. That is why we include Germany for correlations but exclude it from the remaining data analysis.

[3]The selection of countries respond exclusively to the data availability. Ideally, it would be better to use a bigger sample with all countries that run tax cuts as well as subsamples of similar countries which would provide a sort of natural experiment (effect of tax cut on similar economies). We lack PD ratio data for doing that. The selection of the time length has a different motivation. Even though we have series until 2013, we decide to stop at 1995 because tax cuts happened before, and after that financial volatility of the late 90s and 2007-08 took place regardless the relative stability of top tax. Extending the series up to 2013 partially hide the effects of tax cuts over late 80s/first 90s stock market instability. Nonetheless, the analysis does not depend critically on this time selection; extending it until 2013 would not change the general results. PD ratio-tax correlations are still negative and around -0.6 for all countries, except for France (-0.2) and Italy (0.05).

Table 1: Descriptive statistics

	Period	Corr(PD,T)	Average		St Dev	
			PD	T	PD	T
US	1920-30	-0.71	19.06	38.96	4.57	18.78
	1975-95	-0.69	27.07	49.64	6.71	16.12
UK	1920-30	-0.36	21.89	55.63	2.25	5.59
	1975-95	-0.62	21.08	63.19	3.99	21.83
France	1920-30	-0.31	28.85	44.61	5.33	13.83
	1975-95	-0.63	24.25	61.06	8.51	4.24
Italy	1975-95	-0.25	39.55	62.76	13.97	9.37
Netherlands	1975-95	-0.66	20.16	68.38	5.63	5.35
Sweden	1975-95	-0.56	36.94	67.86	18.08	24.21
Germany	1975-95	-0.25	27.39	55.14	6.72	1.39

outcomes. To exploit the historical information contained in the data we have applied two treatments: dynamic panel analysis and impulse-response functions. The dynamic panel data model regress the quarterly first difference of the PD ratio on first difference of both the top marginal income tax rate and the GDP growth (i.e., GDP acceleration). A difference GMM estimation sets out that a 1pp cut in the top tax leads to a 0.16 today and 0.06 tomorrow increase of the PD ratio change, both significant[4]. The inclusion of GDP acceleration as a control does not change the result, but creates an over-identification problem[5]. The dynamic positive impact of a tax cut on the PD ratio change is reported as Fact 4[6]. Results of the dynamic panel model are summarized in Table 2.

Finally, we consider a minimal VAR which includes the first difference of both the PD ratio and the top income tax [7]. We opt for excluding GDP acceleration since it did not affect the way taxes impact over the PD ratio in the dynamic panel estimation. There is no structural model behind; thus, at this point there is no causality claim. Rather, the goal is just to highlight the PD ratio-top tax linear intertemporal interdependencies (this prior is legitimated by the dynamic panel analysis). Figure 2 pictures the impulse response functions[8], showing the impact of a tax shock on the PD ratio first difference for all countries with quarterly data for the period 1975-1995 using a maximum of 8 lags [9]. The general result is that changes in the top tax are associated with ups and downs of the (change of the) PD ratio. In other words, tax cuts will be followed by a stock

[4]In the model without controls, the p-value of the first lag of d_T is 0.055.

[5]The Arellano-Bond estimator requires no autocorrelation (AC) in the idiosyncratic errors. The Arellano-Bond test for AC leads to the no rejection of the absence of second order autocorrelation in both specifications of the model. Over-identification is a problem only for the specification with GDP growth.

[6]Notice that the coefficient for one lag of the GDP acceleration seems to have huge impact on the change of the PD ratio and is highly significant.

[7]Both time series are I(1) for all countries. Tested using a Dickey-Fuller test.

[8]We use non-orthogonalized forms and asymptotic standard errors are plotted at the 95% significance level. Orthogonalization using Cholesky decomposition does not change the results.

[9]For U.S. and U.K. we cut the serie in 1990 just because it depicts clearer the impact of the tax cut. Additionally, notice that the time series of the top marginal income tax rate is very particular: it is just a constant that has some breaks at some specific points. This might cast doubts on the dynamic analysis we run and might call for alternative techniques.

Table 2: Dynamic panel data estimation

Dependent: d_PD		
	(1)	(2)
L.d_PD	0.142	0.148
	(0.199)	(0.184)
L2.d_PD	0.0640	0.0662
	(0.155)	(0.147)
d_T	-0.163*	-0.165*
	(0.0654)	(0.0653)
L.d_T	-0.0644	-0.0634*
	(0.0336)	(0.0309)
d_Growth		-1.128
		(2.133)
L.d_Growth		9.833***
		(2.826)
Constant	0.147	0.145
	(0.0895)	(0.0844)
N	486	486

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

boom after some periods and this boom by a bust. This is Fact 5. On top of that, the additional volatility associated with the shock is transitory (lasting for roughly 8 quarters). This is Fact 6.

All in all, the data analysis has highlighted six tentative facts:

Fact 1. World-wide top marginal income tax cut from 69% to 34% on average.

Fact 2. Negative correlation between the PD ratio and top marginal tax levels (of -0.5 on average).

Fact 3. Positive correlation between volatility of the PD ratio and volatility of the top marginal tax.

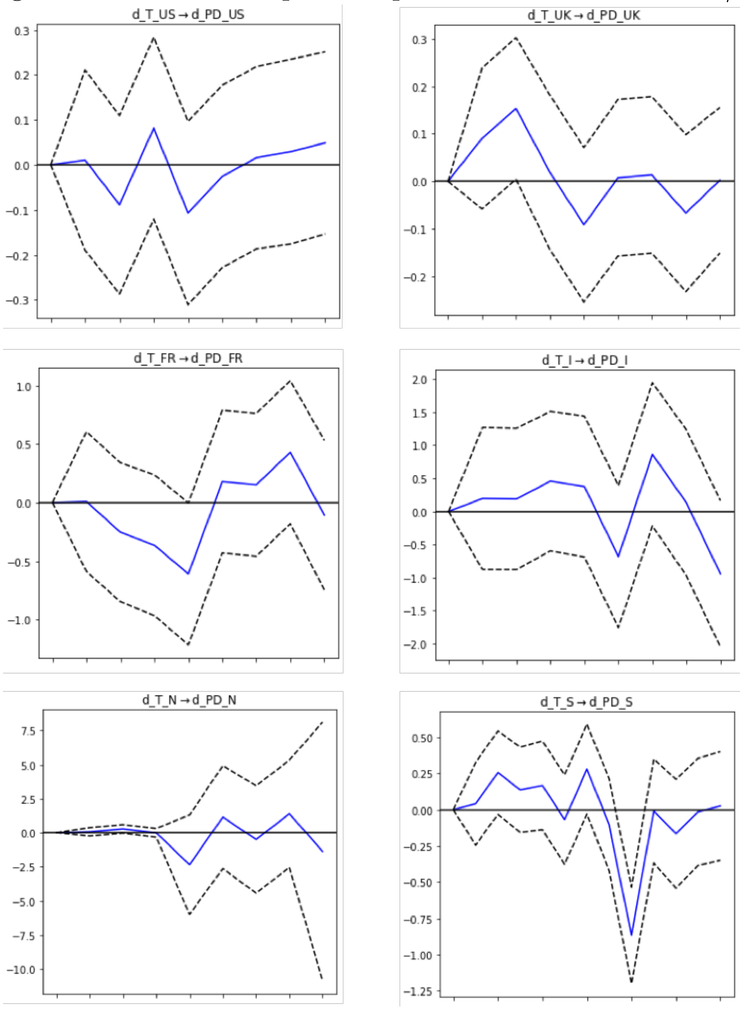
Fact 4. 1pp cut in the top tax leads to a 0.16 today and 0.06 tomorrow increase of the PD ratio change.

Fact 5. Tax cuts are followed by a stock boom after some periods and this boom by a bust.

Fact 6. The additional volatility associated with a tax shock is transitory.

The next step is to build a model that replicates these features making the case for a specific causality, from taxation to PD ratio volatility. But before that, what do we know about the effects of tax cuts?

Figure 2: Estimated impulse response functions 1975-1990/95



2 Related literature

This term paper build on top of two debates: i) how the huge volatility of the stock market might be explained; ii) what are the economic effects of tax cuts. This two debates have grown almost isolated from each other. Our hypothesis builds a bridge between them. A good literature review of the first debate is found in AMN (2016). Here we briefly focus on the literature dealing with the consequences of tax cuts.

First thing to notice is the relatively small body of literature dealing with the the huge 80-90s top tax cuts; this fact has remained relatively unnoticed by the academic literature. To our knowledge, there is only one paper that analyzes the effects of the 1980s-1990s top tax cuts world-wide (panel of 77 countries) (Gwartney & Lawson, 2006; published in a non-economic journal). The remaining literature focused mostly on the U.S.. Secondly, within this small set of works three main topics tax cuts impact on have been highlighted: reported income elasticity, economic growth and income distribution. In terms of reported income, using U.S. data from 1960 to 2000, Saez (2004) found that only the top 1% of income earners shows evidence of behavioral responses to taxation. This is in line with Giertz (2007), who stressed that taxable income elasticity for the 90s was about half the corresponding 80s estimate. Both disagree with Feldstein (1986), who reported evidence for a substantial response of taxable income to changes in marginal tax rates. But the disagreement in the results could be just caused by different time periods data. Another set of literature links taxation with resources allocation, in line with traditional public finance concerns. Boskin (1988) made the case for the limited role of taxes to boost investment, which would be lastly constraint by national savings. In this line, Hurgerford (2012) highlighted that the changes in the U.S. top marginal tax rate and the top capital gains tax rate do not appear correlated with economic growth (uncorrelated with saving, investment and productivity growth). Piketty et al. (2011) showed evidence from 18 OECD that backed that infertility of top tax cuts. But this is not a consensus. For the U.S., Holcombe & Lacombe (2004) run a county-based analysis from 1960 to 1990, stating that states that raised their top income tax rates more than their neighbors had slower income growth and, on average, a 3.4 percent reduction in pc income. Globally, Gwartney & Lawson (2006) reported that top rates of 50% or more more have an adverse impact on long-term economic growth. The impact of top tax cuts on inequality seems to be less controversial. Many different studies using data for different contries found that top tax cuts raises personal inequality (Gwartney & Lawson (2006), Piketty et al. (2011), Hurgerford (2012), Alvaredo et al. (2013), etc.). Beyond that, there is a set of literature linking corporate taxation and firm value. Important works on this area are performed by Summers and coauthors, who used a Q-investment theory à la Tobin (1969) to link stock value with real outcomes (see Summers et al. (1981), Poterba & Summers (1984), Goulder & Summers (1987), etc.). Nonetheless, this corporate literature is a bit distant of our topic.

To our knowledge, there is only one paper that explicitly links changes in the top marginal income tax rates with changes in stock prices: McGrattan & Prescott (2001). They hypothesize that the long-run rise in the equity value with respect to the GDP is due to the fact that the average tax rate on dividends fell dramatically between 1962 and 2000. That fall was because of both top tax cuts and the increase in the share of stocks held by non-tax-paying entities (pension funds and the likes). In a recent report of the Tax Policy Center, Rosenthal & Austin (2016) showed that only about 25% of U.S. corporate stock is held in taxable accounts (while about 80% was taxed in 1965). Notice that the McGrattan & Prescott' work focus on long-run capitalization rather than in the instability of the stock market, so it does not address the question we are dealing with. Besides, the decrease of taxable corporate stocks is in fact a tax cut that partially reinforces the evidence of section 1[10] and additionally motivates the model.

[10]We are not directly claiming that the reduction of the taxable corporate stocks is automatically a top tax cut. The distribution of these stocks should be analyzed. However, given the well-documented high concentration of assets might legitimate the prior of this as a top tax cut

3 The model: AMN(2016) with taxes

The model presented here is an extension of the Adam, Marcet & Nicolini (2016) model, (i.e., a standard consumption-based asset pricing model with internal rationality). That model replicates the PD ratio volatility assuming a tax-free world. We remove that assumption, bringing in an income tax. Specifically, the income tax takes a form of a dividend tax. The main claim we do here is that the dividend tax is a proxy for the top income marginal tax. It pictures an economy in which the additional income that is taxed at the highest rate comes completely from dividends. This assumption has some empirical backing. First, the 1913-2014 average share of dividend income on total income is 30.7% for the U.S. top 1% [11]. That share decreases with income levels, which means that dividends accrue mostly to the rich, making plausible the idea that the top marginal income tax is a dividend tax. Second, in general dividends are taxed as any other type of income; only qualified dividends are subject to a privileged taxation scheme[12]. The dividend tax impacts through two different channels. First, it enters the budget constraint in a standard way, decreasing available resources and changing the effective relative return of stocks. Second, it affects the expectation formation process: investors take into account the effect of relatively recent changes of taxes on tomorrow's capital gains. This two-side mechanism makes taxes a powerful driver of the PD ratio.

3.1 Model structure

Demographics The economy is populated by a continuum of measure 1 of infinitely living investors.

Income process When the time starts, each agent is initially endowed with one unit of stock S_t; Each stock yields an exogenous dividend D_t which is time fluctuating. In addition, at the beginning of each period, she receives W_t units goods (which one might call wages). Then, the flow of income at the beginning of the period is $W_t+(1-\tau_t)D_t$, which determines the upper bound for consumption C_t^i . The introduction of wages captures the fact that the observed consumption dynamics are less volatile than the dividend dynamics, while keeps the correlation between dividend and consumption growth. Dividends evolves according to

$$\frac{D_t}{D_{t-1}} = a\epsilon_t^d \tag{1}$$

where $a \geq 1$ stands for the permanent component and $\epsilon_t^d \sim \log\mathcal{N}(1, e^{s_d^2} - 1)$ for the random (unpredictable) shock (this is one source of uncertainty). Instead of specifying a process for the other exogenous variable W_t, we set up a specific aggregate consumption process which under the right calibration resembles the empirical aggregate consumption process

$$\frac{C_t}{C_{t-1}} = a\epsilon_t^c \tag{2}$$

[11] Data for this calculus comes from Piketty et al. (2018).

[12] Dividends are labeled as qualified if i) they are paid by a U.S. corporation, a corporation incorporated in a U.S. possession, or a foreign corporation that is listed on a major U.S. stock exchange; ii) the investor owns the stock for more than 60 days within a 121-day holding period.

where $\epsilon_t^c \sim \log\mathcal{N}(1, e^{s_c^2}-1)$. Besides, $(\epsilon_t^d, \epsilon_t^c)$ are log Normal jointly distributed. The process for W_t is implied by feasibility. Sequences $\{\tau_t\}_{t=0}^{\infty}$ have no random component and are orthogonal to dividends and consumption.

Goods and assets $\{D_t, W_t\}$ take the form of a perishable consumption good (single good economy). S_t is a financial contract that promises the payment of D_t goods each period. Note that risk-free bonds are not included; the implicit assumption is that actual bond prices and agents' expectations lead to an optimal zero-bonds-forever plan ($B_t^* = 0 \;\; \forall t$)[13]. Thus, the only way of transferring present value to the future is through stocks.

Markets Stock market is competitive but incomplete (i.e., absence of forward state-contingent assets). A negative amount of stocks is allowed up to some point (specified below). Goods market behaves also competitively. Then, prices are such that markets clear. Notice that prices are in fact relative prices (normalized by the price of the consumption good).

Agents There exist two agents:

Government The government finances its expenditure G_t by imposing a proportional tax τ_t on dividends. The budget is balanced each period (i.e., $G_t = \tau_t D_t \;\; \forall t$)[14].

Investor Each investor faces a consumption-saving decision: she chooses sequences of consumption and stock holdings $\{C_t^i, S_t^i\}_{t=0}^{\infty}$. Her state space Ω is made of the realizations of the four internally exogenous processes (i.e., taken as given by investors), being $\omega = \{D_t, W_t, P_t, \tau_t\}_{t=0}^{\infty}$ a typical element of Ω. Notice that this deviates from traditional models (with RE or even with Bayesian RE) in which the states are only fundamental variables (dividends, wages and taxes in this case). That models build on the assumption that agents know the exact mapping from the fundamentals history to current prices. That assumption is relaxed here: instead of having an exact forecast of $P_t \mid (D^t, W^t, \tau^t)$, each investor has a probabilistic view (an entire distribution) of P_t conditional on the states history. This gives rise to a larger state space (and to an additional source of uncertainty (how fundamentals map into prices)). Thus, the underlying probability space is given by $(\Omega, \mathcal{B}, \mathcal{P})$ with $\mathcal{B}$ denoting the corresponding σ-algebra of Borel subsets of Ω and $\mathcal{P}$ the agent's subjective probability measure over $(\Omega, \mathcal{B})$.

Each investor behaves rationally conditional on her representation of the world (i.e., she does her best based on what she expects to happen). This Internal Rationality is a deviation from the (External) Rational Expectations assumption. Formally, her representation of the world boils down to a well-defined system of subjective probability beliefs (represented here by the probability measure $\mathcal{P}$) about the exogenous variables that she uses to optimally solve her program. This system of beliefs may correspond or

[13]This departs from AMN (2016) but follows Adam, Marcet and Beutel (2017). Removing this assumption preserves the results while keeps the exposition simpler.

[14]Then, feasibility is given by $C_t + G_t = W_t + D_t$ or equivalently $C_t = W_t + (1-\tau_t)D_t \quad \forall t$.

not with the true model; in this sense, the Internal Rationality assumption is more general than RE. The processes for fundamentals (wages, dividends and taxes) are common knowledge. This diverges from the Bayesian RE literature (in which agents learn about fundamentals). On top of that, rationality implies a learning process: agents correct the way they expect prices behaves in the light of their new realizations (the learning rule is specified below). Thus, uncertainty comes from the random component of dividends and consumption and price realizations.

In conclusion, each investor has two controls $\{C_t^i, S_t^i\}$, four states $(\{D_t, W_t, P_t, \tau_t\}_{t=0}^{\infty}$, knows how the fundamentals evolve and learn about stock prices. Thus, the investor i program reads

$$\max_{\substack{\{C_t^i, S_t^i\}_{t=0}^{\infty} \in \Gamma \\ S_{-1}=1}} E_0^{\mathcal{P}} \sum_{t=0}^{\infty} \delta^t \frac{C_t^{i1-\gamma}}{1-\gamma} \tag{3}$$

where

$$\Gamma = \left\{ C_t^i, S_t^i \ \mid \ C_t^i + P_t(S_t^i - S_{t-1}^i) \leq W_t + (1-\tau_t) D_t S_{t-1}^i; \ \underline{S} \leq S_t^i \leq \bar{S} \right\} \tag{4}$$

$U : R \longrightarrow R$ is assumed to be a time-separable continuous, increasing in consumption $U'(C_t) > 0$ but strictly concave $U''(C_t) < 0$ function. Inada conditions hold. This parametric specification of U represents a risk averse investor (specifically a CRRA investor). Γ sets up the feasible set. Lower and upper bound on S_t are assumed for convenience; mathematically, that bounds ensure that the feasibility set is compact and, given the continuity of U, the existence of a maximum is guaranteed by the Weierstrass theorem; economically, the lower bound rules out Ponzi schemes, which are out of interest here. Notice that we have introduced taxes in the budget constraint. It potentially makes the stock relatively more profitable (substitution effect) and increases the available resources of the investor (income effect). This is the first channel.

3.2 Analytical results

The concavity of the investor' i program and the convexity of the feasible set guarantee the sufficiency of the first order conditions (FOC) for an optimal (interior) plan. These conditions boils down to

$$P_t = \delta E_t^{\mathcal{P}} \Big[\Big(\frac{C_{t+1}^i}{C_t^i} \Big)^{-\gamma} (P_{t+1} + (1-\tau_{t+1}) D_{t+1}) \Big] \tag{5}$$

which basically points out that the stock price today is the discounted subjective expectation of the net-of-taxes value that stocks yields tomorrow. Nevertheless, the Efficient Markets Hypothesis fails to hold. This is because of, under the general specification we set up, the Law of Iterated Expectations cannot be applied since the identity of the marginal investor that actually prices the stock is changing over time $(E_t^{\mathcal{P}_i}(E_{t+1}^{\mathcal{P}_j}(E_{t+2}^{\mathcal{P}_k}(...))$. But even if we impose the additional assumption of homogeneous beliefs, EMH does not work. To see that, iterating forward (5) and applying the standard transversality condition

$$P_t = E_t^{\mathcal{P}}\left[\sum_{j=0}^{\infty}\delta^j\left(\frac{C_{t+j}^i}{C_t^i}\right)^{-\gamma}(1-\tau_{t+j})D_{t+j}\right] \tag{6}$$

which points out that P_t depends on future consumption which in turn depends on future prices which in turn depends of today prices given that agents learn from it. Notice that in general, $C_t^i \neq C_t$ and then the knowledge about the aggregate consumption process is not really useful for forecasting individual consumption. Even with the homogeneity assumption (in which case the ex-post equilibrium would be $C_t^i = C_t = W_t + (1-\tau_t)D_t$ and the three variables of the LHS would be known by the representative investor), ex-ante $E_t^{\mathcal{P}}(C_t^i) \neq E_t^{\mathcal{P}}(C_t)$, unless we additionally assume that the homogeneity of beliefs is common knowledge. As a result, equation (6) only imposes restrictions about what the investor may believe about prices if we assume homogeneous beliefs and common knowledge about them. See AMB (2017) for a detailed discussion. Here we do not make these restrictive assumptions.

The introduction of taxes has many implications. First, the standard RE equilibrium result changes.

Result 1: Under Rational Expectations and the usual transversality condition[15] *the equilibrium* PD^{RE} *ratio stops being a constant and becomes a negative function of future taxes.*

In this more general version,

$$\frac{P_t^{RE}}{D_t} = \frac{\lambda\rho(1-\tau_{t+1})}{1-\lambda\rho(1-\tau_{t+1})} \tag{7}$$

where $\lambda = \delta a^{1-\gamma}$ and $\rho = e^{\gamma(1+\gamma)s_c^2/2}e^{-\gamma\rho_{cd}s_c s_d}$. As a result

$$Var\left(ln\left(\frac{P_t}{P_{t-1}}\right)^{RE}\right) \approx Var\left(ln\left(1-\frac{\lambda\Delta\tau_t}{1-\lambda(1-\tau_{t+1})}\right)\right) + Var\left(ln\frac{D_t}{D_{t-1}}\right) \tag{8}$$

which under either constant taxes ($\tau_t = \tau \;\; \forall t$) or zero taxes ($\tau_t = 0 \;\; \forall t$) reproduces the standard RE result $\frac{P_t}{P_{t-1}} = \frac{D_t}{D_{t-1}}$ that implies a constancy of the PD ratio. Nevertheless, in general, the PD^{RE} ratio varies negatively with taxes. Even so, the PD^{RE} still fails to replicate the observed PD volatility, given the relative stability of taxes.

Second, a dividend tax also modifies the result under learning got in AMN (2016). To obtain the equilibrium we invoke Assumption 1 in AMN (2016) that allows us to substitute $\left(\frac{C_{t+1}^i}{C_t^i}\right) = \left(\frac{C_{t+1}}{C_t}\right)$

[15] Iterating forward (5) and assuming RE and $\delta \in [0,1]$, $\lim_{j\to\infty}\delta^j a^{-j\gamma}E_t(P_{t+j}) = 0$ holds true and (6) comes up.

[16]. Using this result, the subjective expectations of risk-adjusted capital gains are defined as

$$\theta_t \equiv \beta_t \left(1 - \sum_{j=-1}^{J} \alpha_j (\tau_{t-j} - \tau_{t-1-j})\right)^{\mu} = E_t^{\mathcal{P}}\left[\left(\frac{C_{t+1}}{C_t}\right)^{-\gamma} \frac{P_{t+1}}{P_t}\right] \tag{9}$$

This is the second piece which tax impacts on. The intuition is that investors takes into account the effects of recent changes of taxes to form capital gains expectations, believing that tax cuts will increase demand for stocks (because of both substitution and income effects) and then, stock prices. In other words, they are aware of how taxes impact its individual budget constraint and re-scale to the whole market that rationale (in a sort of alleged aggregate rationality). Notice that we introduce first difference tax lags to capture the fact that the impact of a tax cut might appear some periods later (as we reported in the facts section). Parameter α_j captures the weight assigned to each lag, imposing a convex combination of them (i.e., $\sum_{j=-1}^{J} \alpha_j = 1$); J establishes the number of lags considered; notice that j starts at -1, meaning that tomorrow's first difference might also be relevant for expectations about tomorrow capital gains. On top of that, the parameter $\mu \in [0,1]$ captures the relevance of tax changes on subjective expectations (for $\mu = 0$, we are back to the AMN (2016) expectations formulation; but even in this case, results would differ since taxes appear also in the budget constraint).

Result 2. Under subjective beliefs on capital gains, the equilibrium PD ratio is monotonically decreasing in taxes and increasing in the non-tax component of beliefs (β_t). That is

$$\frac{P_t}{D_t} = \frac{\lambda\rho(1-\tau_{t+1})}{1-\delta\theta_t} \tag{10}$$

provided that the denominator is positive (i.e. $\theta_t < \delta^{-1}$). As a result, the volatility of stock prices is potentially much higher than the volatility of dividends

$$Var\left(ln\left(\frac{P_t}{P_{t-1}}\right)\right) \approx Var\left(ln\frac{1-\tau_{t+1}}{1-\tau_t}\right) + Var\left(ln\frac{1-\delta\theta_{t-1}}{1-\delta\theta_t}\right) + Var\left(ln\frac{D_t}{D_{t-1}}\right) \tag{11}$$

Notice that we split the extra volatility in two parts, the one coming from the budget constraint (first term of the RHS) and the one coming from the expectation formation (second term of the RHS). In other words, the introduction of taxes is able to potentially affect a lot the volatility of the PD ratio.

The key feature of the AMN (2016) model is the self-referential process, that is, a perceived-realized capital gains loop. The introduction of taxes does not change this feature. On the one

[16] Assumption 1 supposes that W_t is sufficiently large w.r.t. D_t and that the subjective expectation of tomorrow PD ratio is bounded (above). The marginal role that it assigns to dividends does not fit well the model we present here in which dividends are quantitatively important. The model must be corrected in this direction, following AMB (2017).

hand, the realized price growth is a function of non-tax beliefs and taxes

$$\frac{P_t}{P_{t-1}} = T(\{\tau_{t-j}\}_{j=-1}^{J}, \beta_t, \beta_{t-1})\epsilon_t^d \tag{12}$$

where

$$T() = \frac{a(1-\tau_{t+1})}{1-\tau_t}\left(a + \frac{a\delta\beta_t\left(1-\sum_{j=-1}^{J}\alpha_j(\tau_{t-j}-\tau_{t-1-j})\right)^{\mu} - a\delta\beta_{t-1}\left(1-\sum_{j=0}^{J+1}\alpha_j(\tau_{t-j}-\tau_{t-1-j})\right)^{\mu}}{1-\delta\beta_t\left(1-\sum_{j=-1}^{J}\alpha_j(\tau_{t-j}-\tau_{t-1-j})\right)^{\mu}}\right) \tag{13}$$

The T-mapping links perceived to actual capital gains. If $\mu = 0$ (no taxes on expectation formation) and $\tau_{t+1} = \tau_t$, equation (13) takes the AMN (2016) form. On the other hand, the learning rule that specifies how agents update their beliefs β_t adjusts to capital gains realizations. In general

$$\Delta\beta_t = f\left(\left(\frac{C_{t-1}}{C_{t-2}}\right)^{-\gamma}\frac{P_{t-1}}{P_{t-2}}\left(1-\sum_{j=-1}^{J}\alpha_j(\tau_{t-j}-\tau_{t-1-j})\right)^{-\mu}; \beta_{t-1}\right) \tag{14}$$

where f is a non-linear updating function that satisfy same properties as in AMN (2016). A feedback between expected and realized capital gains emerges from the (12) & (14) system. Under this scheme, both the momentum and the mean reversion results hold.

4 Quantitative analysis

In order to assess the quantitative properties of the model, we simulate it. In order to do so, some of the general forms are now specified. In particular, the learning rule will be

$$\beta_t = \beta_{t+1} + \frac{1}{\psi_t}\left(\left(\frac{C_{t-1}}{C_{t-2}}\right)^{-\gamma}\frac{P_{t-1}}{P_{t-2}}\left(1-\sum_{j=-1}^{J}\alpha_j(\tau_{t-j}-\tau_{t-1-j})\right)^{-\mu} - \beta_{t-1}\right) \tag{15}$$

where the gain sequence $1/\psi_t$ weights past prediction errors. Here we assume a simple recursive specification

$$\psi_t = \psi_{t-1} + 1 \tag{16}$$

given $\psi_1 = 0.2$. Additionally, we have used the projection facility used in AMN (2016; 2015 version) to ensure that the perceived capital gains are below the upper bound we set up before. Mathematically, we need them to have a well defined denominator in (10) and then in the price growth expression. The economic intuition is that if the realized price growth implies too crazy beliefs investors simply rule out this observation. Table 3 set up the parameter values. The strategy has been to fix AMN (2016) model' parameters in some of the values used in that work and to play only with the new parameters we have introduced (μ and $\{\alpha_{t-j}\}_{j=-1}^{J}$) in order to check some properties of the model. That is why table 3 does not contain values for the new parameters.

Table 3: Parameter specification

δ	γ	a	s_d	s_c	ρ_{cd}
0.999	5	1.0035	0.3	$s_d/7$	0.2

Testing AMN (2016)

Unlike other consumption-based asset-pricing models, AMN (2016) is able to generate enough volatility of the PD ratio by introducing the perceived-realized capital gains loop. One of the assumptions is a tax-free economy. The first test presented here is to introduce taxes in that set up in the simplest possible way, as a constant tax ($\tau_t = \tau \ \forall t$). Following the empirical evidence of section 1, we set up $\tau = 0.3$, which is close to the average top income marginal tax rate after tax cuts. Remind that constant taxes restore the AMN (2016) expectation formation process. In other words, the test is set up in such a way that gives AMN (2016) the highest chances to do well. A Montecarlo experiment (500 simulations) have been conducted to test its properties in the dimensions we are interested in. The results are:

- The simulated relative volatility (i.e., standard deviation over the sample mean) is 0.09 front the 0.51 pointed out as a Fact 1 by AMN (2016).
- The simulated persistence (i.e., autocorrelation) is -0.06 vs 0.97 pointed out as Fact 2.

In other words, AMN(2016) is unable to replicate the real-world volatility and persistence[17] once kind-of-real-world taxes are inserted on it. In this set up, taxes just swallow the whole volatility, emerging as a powerful stabilizer. This might lead to a normative approach: what should be the tax rule that rules the huge stock fluctuations out. (...)

Testing the Model

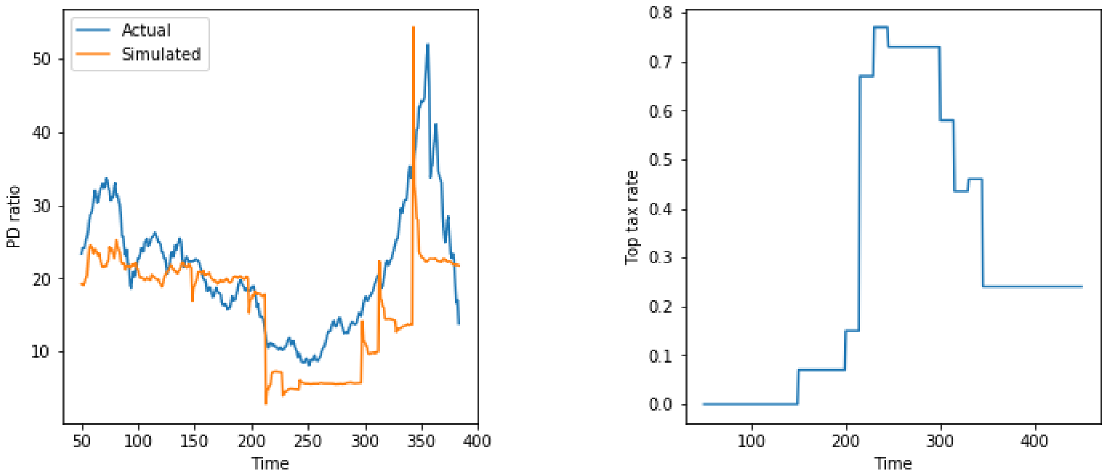
We calibrate our model with actual top tax time series and compare the simulated PD ratio with the actual monthly PD ratio for the U.S. The years selected are 1900-1930. The reason is that this period started with zero top tax and witnessed a rise and fall of it. Then, beyond to section 1 facts, we have an additional benchmark that allows us to test the performance of the model not only with respect to tax cuts but also to tax raises. For the calibration, apart from values specified on table 3, we set up the following parameter values: $J = 4; \alpha_{-1} = 0.5; \alpha_0 = 0.15; \alpha_1 = 0.15; \alpha_2 = 0.1; \alpha_3 = 0.1; \mu = 0.25$ [18]. Figure 3 pictures the simulation results against actual US 1900-1930 data.

A visual analysis would point out that our model replicates the negative correlation (fact 2) but i) it overstates the size of the PD response to a tax shock and ii) it lacks of persistence (huge

[17] The lack of correlation is an outcome of the Montecarlo experiment. In one-time simulation, the relative volatility is still very low (0.05) but the persistence is very high (0.95). On behalf on comparability, in table 4 we use this one-time simulation results.

[18] The selection of the number of lags is a bit arbitrary, but tried to use the information we got from the IRF in section 1. We have tested the model for different number of lags with different weights and different μ. Over-reaction of the PD ratio to tax shocks remained.

Figure 3: Actual and simulated PD ratio and actual top marginal income tax rate evolution



jumps). However, the statistics of the model sets out that it does reasonable well in terms of relative volatility and persistence, fixing somehow the problem of a simple introduction of taxes in the AMN (2016) model.

Table 4: Comparative moments

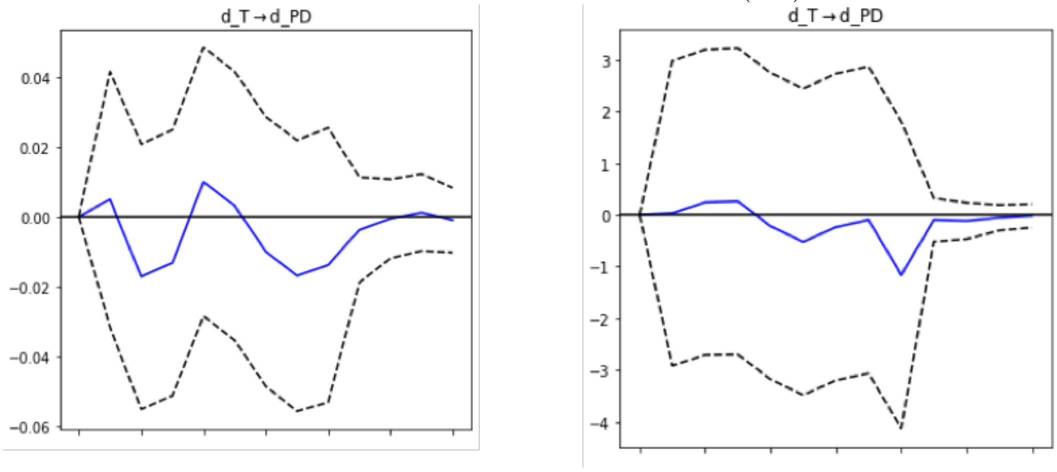
	AMN Facts	AMN simple tax	Model	US 1900-1930
Relative volatility	0.51	0.05	0.41	0.4
Persistence	0.97	0.95	0.92	0.99

Finally, we compare the impact of actual tax shocks on both real and simulated PD ratio, using again IRF. The visual analysis sets out that our model is able to replicate quite well the fluctuations generated by tax shocks and the transitory character of their effects. Note that this is in line with Facts 5 & 6 (section 1). However, the amplitude of the confidence intervals is excessive (which has to do with the overstatement of the response of the PD ratio to the tax shock).

5 Conclusion

The XXth century has witnessed huge changes in tax policies (both strong rises and falls). This is specially true for the top marginal income tax rate. We documented that it decreased a lot the last decades of the XXth. So far, the skinny academic literature on this topic focused on the effect of the tax cut on income reported elasticity, economic growth or income inequality. We explore a different effect: how tax cuts might generate stock prices bubbles. First, we presented some exploratory facts: strong negative correlation between the PD ratio and the top tax; positive correlation between their standard deviations; booms and busts associated with tax shocks; transitory effects of tax shocks. These facts both legitimate this prior and call for a causal explanation. To address the causality, we introduced taxes in a well-behaved asset-pricing model. We do so through

Figure 4: Estimated IRF for real tax shocks and both real PD (left) and simulated PD (right)



two channels: i) the budget constraint, triggering both a substitution and an income effect in the direction of increasing the demand for stocks; ii) the process of expectation formation, capturing the expectations bubbles that tax changes might create. The quantitative assessment of the model set out that it behaves reasonably well in a number of dimensions (relative volatility, persistence and dynamic properties).

Nonetheless, many shortcomings came up. First and foremost, the limited available data for the PD ratio blocked prevented us from reaching the frontier of possibilities of this research question. Almost 80 countries around the world cut top taxes during the 80s and 90s. This provides a potential natural experiment (how do top tax shock impact on financial stability in very similar countries on the same period?). Second, a call for caution is crucial: tax systems are complex animals, full of exemptions and small letters. Here we focus only on nominal top income tax rate, abstracting from many important facts (e.g., changes in rates' thresholds, the huge change from taxable to non-taxable holders, etc.). All of that will potentially change the picture. Third, the data analysis we run should be taken with a pinch of salt; tax time series are somehow special; both N and T were too small, etc. Fourth, the model we used is not very well prepared to deal with high dividends; besides, it is a partial equilibrium model that takes many things from outside. Endogeneizing some of the processes would make it potentially more powerful (for instance, introducing a capital gains-dividends loop). Last but not least, understanding financial instability requires more than tax shocks: in the dynamic empirical analysis we pointed out that GDP acceleration seems to play an important role; other empirical evidence set out the relevance of credit booms to understand financial instability; and so on. All that points out the way forward.

6 References

(...)

7 Appendix

7.1 Data Sources

PD: GFD & Shiller. GDP: GFD & NIPA. Taxes: IRS, OECD, Gwartney, Piketty, Reynols.(...)

7.2 Top tax cuts 1979-2002

Graph 1 pictures the two more distant points for each country. The sample does not aim to be nor exhaustive neither representative. Its goal is just to ilustrate the huge phenomenon of top tax cuts that took place the last decades of the XXth.

Table 5: Top marginal income tax rate for a set of countries.

Country	1979	1990	2002
Belgium	76	55	55.6
Bolivia	48	10	13
Botswana	75	50	25
Brazil	55	25	28
Canada	64	49	34
Colombia	56	30	35
Dominican Rep.	73	73	25
Egypt	80	65	40
Finland	71	43	53.8
India	60	50	30
Iran	90	75	35
Ireland	65	42	66
Italy	72	50	52
Jamaica	58	33	25
Japan	93	50	50
Malaysia	60	45	28
Mauritius	50	35	25
Mexico	55	40	35
New Zealand	60	33	39
Nigeria	70	55	25
Norway	75	54	48
Peru	65	45	30
Philippines	70	35	32
Portugal	84	40	40
Puerto Rico	79	43	33
Russia		60	13
Singapore	55	33	26
South Korea	89	50	36
Sweden	87	20	56
Trinidad & Tobago	70	35	35
Turkey	75	50	40
UK	83	40	40
US	70	33	39