

Public Economics
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Thomas Piketty
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**Lecture 10: Optimal Taxation of Capital
Income, Inheritance and Wealth**
(check [on line](#) for updated versions)

Roadmap of lecture 6

- Summary of today's theoretical results
- Warning: capital mobility raises elasticities
- Basic theoretical results on zero capital taxes
- Four main reasons for taxing capital
- The incentive argument for wealth taxation
- The optimal taxation of inheritance
- A different view on capital taxation: immaterial capital, broadband and « unique » assets

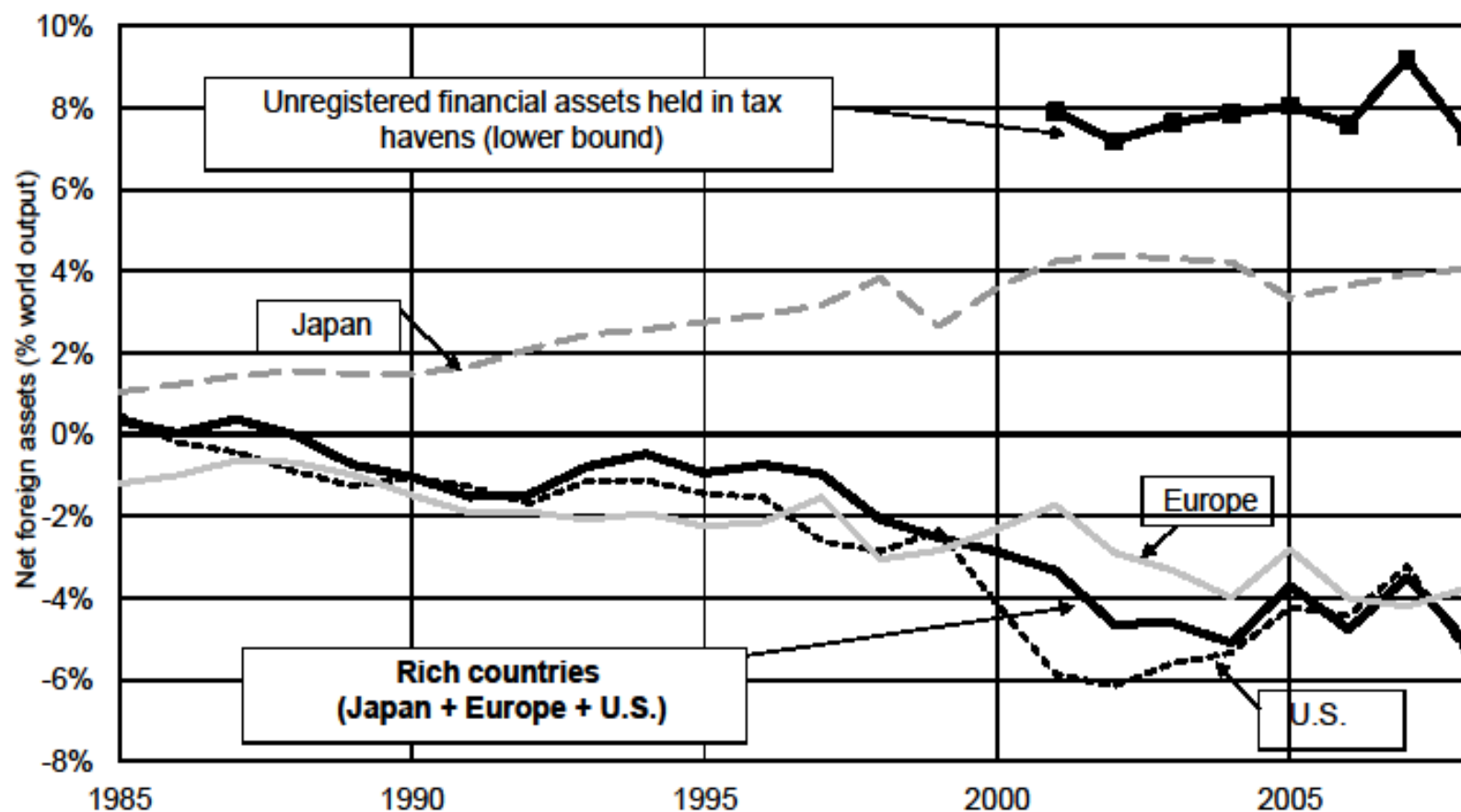
Summary of today ' s theoretical results

- One reason for not taxing capital: if full information on k income flows + k accumulation = 100% life-cycle wealth (zero inheritance) + perfect capital markets, then there is no reason to tax capital (**Atkinson-Stiglitz**)
- Four main reasons for taxing capital:
- « **Fuzzy frontier argument** »: if the frontier btw labor and capital income flows not so clear (e.g. for self-employed), then it is better to tax both income flows at rates that are not too different
- « **Fiscal capacity argument** »: if income flows are difficult to observe for top wealth holders, then wealth stock may be a better indicator of the capacity to contribute than income
- « **Incentive argument** »: by taxing the capital stock rather than the income flow, agents are given incentives to get higher returns
- « **Meritocratic argument** »: individuals are not responsible for their inherited wealth, so maybe this should be taxed more than their labor income; imperfect k markets then imply that part of the ideal inheritance tax should be shifted to lifetime k tax
- See Piketty-Saez-Zucman « Rethinking capital and wealth taxation », [2013](#)

Warning: in practice, it is difficult to tax capital with capital mobility and little international coordination

- Without fiscal coordination (automated exchange of bank information, unified corporate tax base, etc.), all forms of k taxation might well disappear in the long run, whatever the true social optimum might be
- On these issues see the following papers:
- G. Zucman, “The missing wealth of nations”, [QJE 2013](#)
- **G. Zucman, “Taxing Across Borders: Tracking Personal Wealth and Corporate Profits”, [JEP 2014](#)**
- N. Johanssen and G. Zucman,, "The End of Bank Secrecy? An Evaluation of the G20 Tax Haven Crackdown", [WP 2012](#)
- K. Clausing, "In Search of Corporate Tax Incidence", [WP 2011](#)
[Tax Law Review 2012](#)
- N. Rousille, “Tax evasion & the Swiss cheese regumation”, [2015](#)

Figure 12.6. The net foreign asset position of rich countries



Unregistered financial assets held in tax havens are higher than the official net foreign debt of rich countries.

Sources and series: see piketty.pse.ens.fr/capital21c.

Table 1

The World's Offshore Financial Wealth

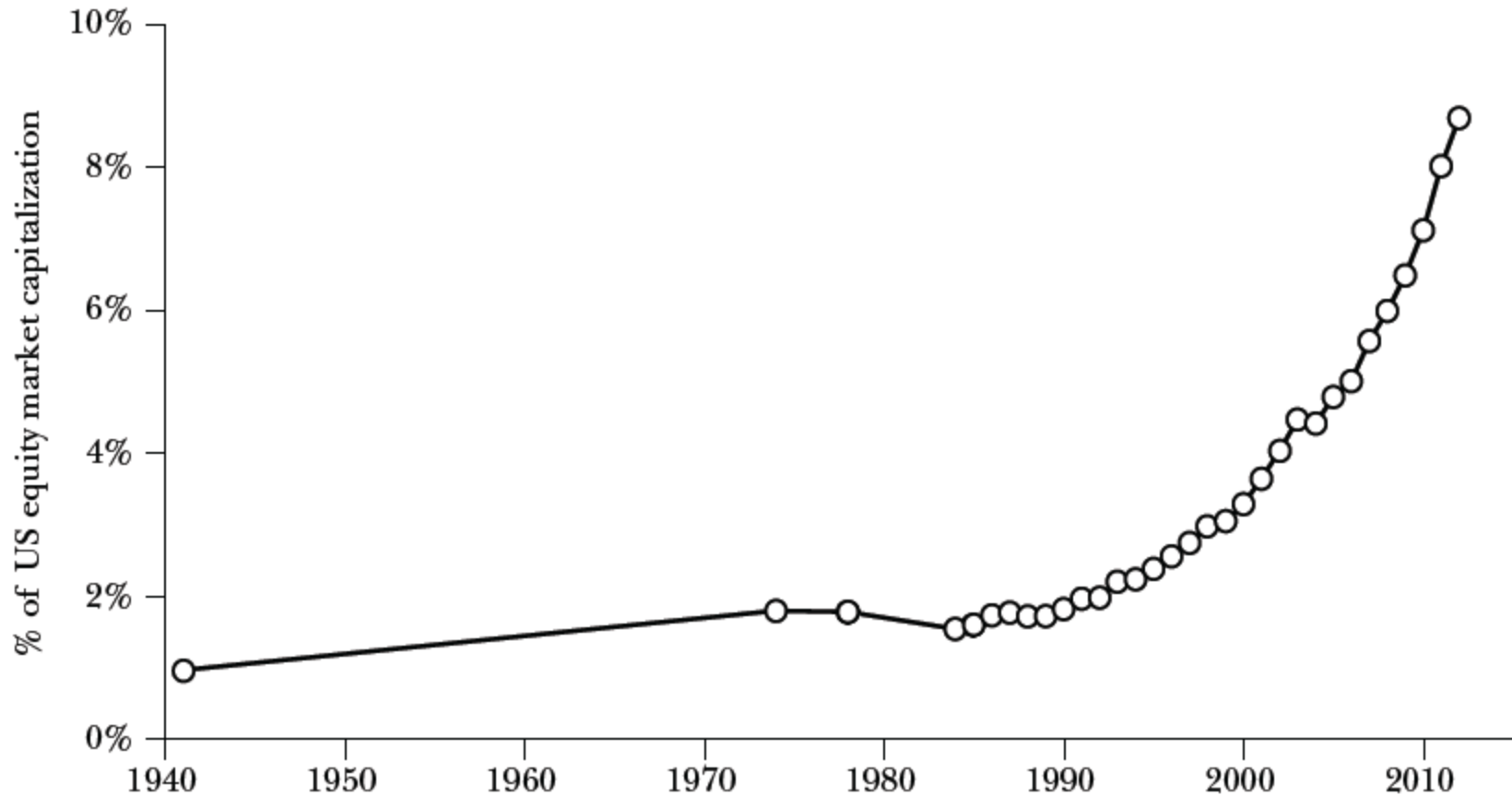
	<i>Offshore wealth</i> (\$ billions)	<i>Share of financial</i> <i>wealth held offshore</i>	<i>Tax revenue loss</i> (\$ billions)
Europe	2,600	10%	75
United States	1,200	4%	36
Asia	1,300	4%	35
Latin America	700	22%	21
Africa	500	30%	15
Canada	300	9%	6
Russia	200	50%	1
Gulf countries	800	57%	0
Total	7,600	8.0%	190

Source: Author's computations (see Zucman 2013a, b) and online Appendix.

Notes: Offshore wealth includes financial assets only (equities, bonds, mutual fund shares, and bank deposits). Tax revenue losses only include the evasion of personal income taxes on investment income earned offshore as well as evasion of wealth, inheritance, and estate taxes.

Figure 6

US Equities Held by Tax Haven Firms and Individuals



Source: Author's computations using US Treasury International Capital data. See online Appendix.

Notes: In 2012, 9 percent of the US listed equity capitalization was held by tax haven investors (hedge funds in the Cayman Islands, banks in Switzerland, mutual funds in Luxembourg, individuals in Monaco, etc.)

Figure 2

The Share of Tax Havens in US Corporate Profits Made Abroad

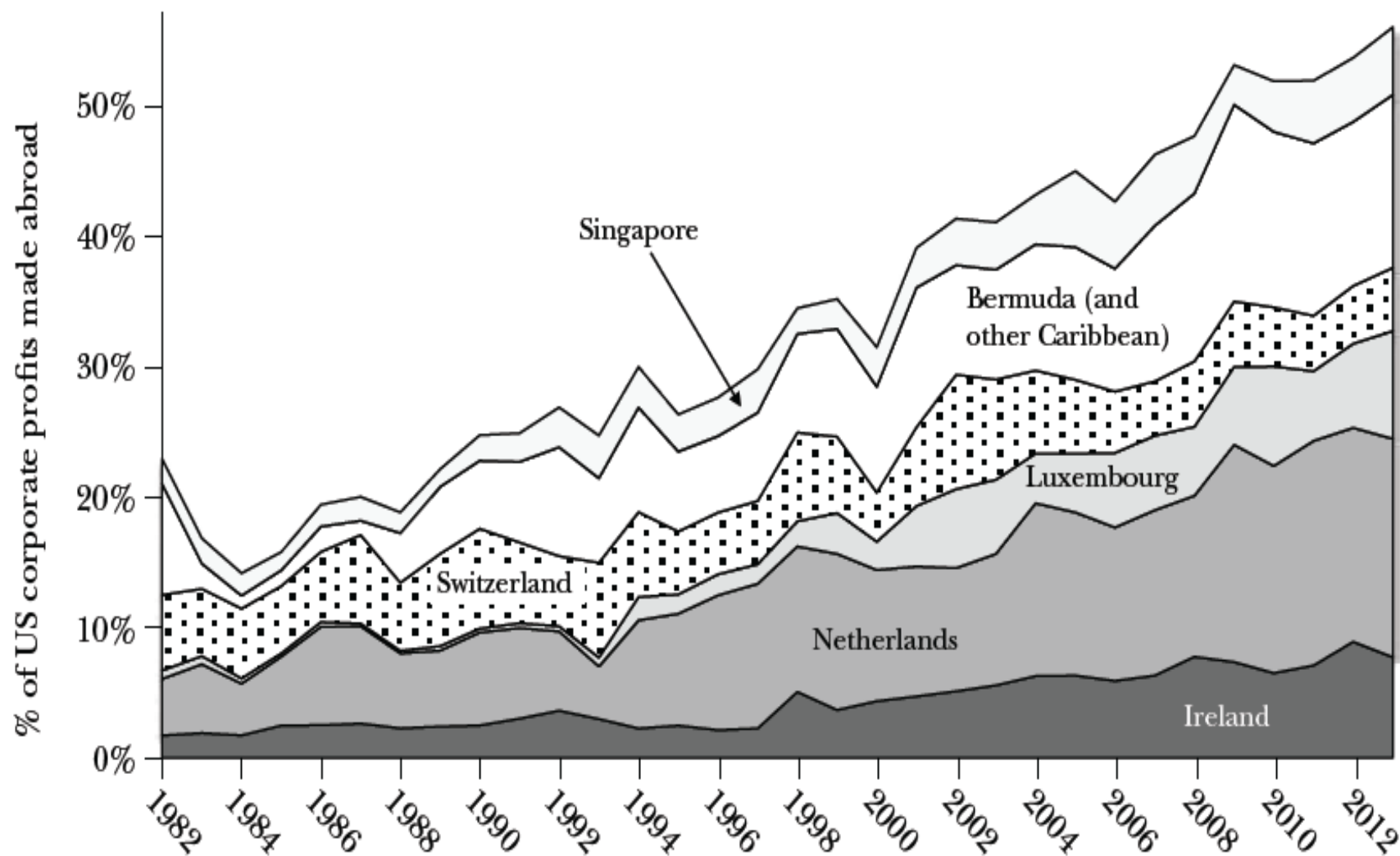
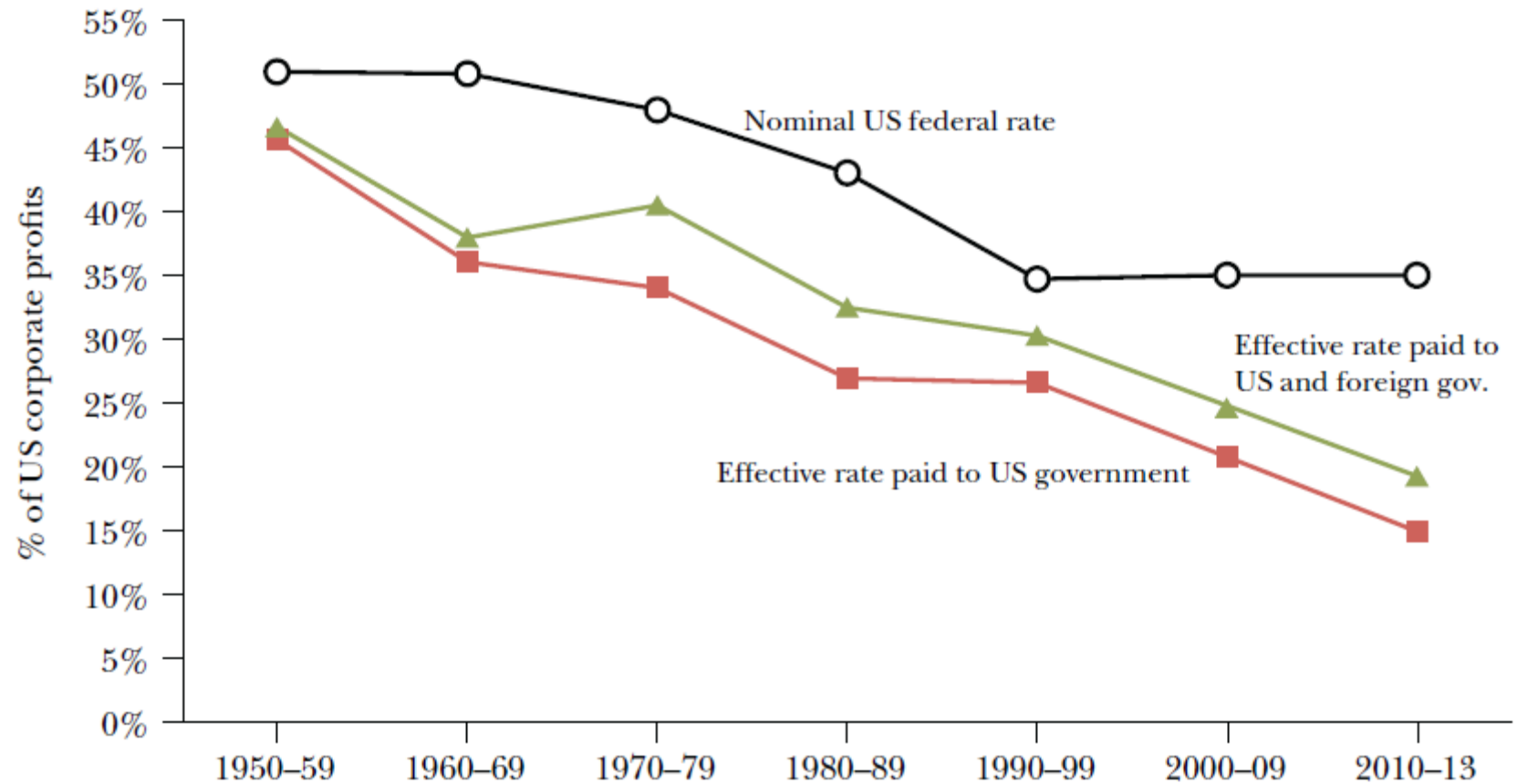


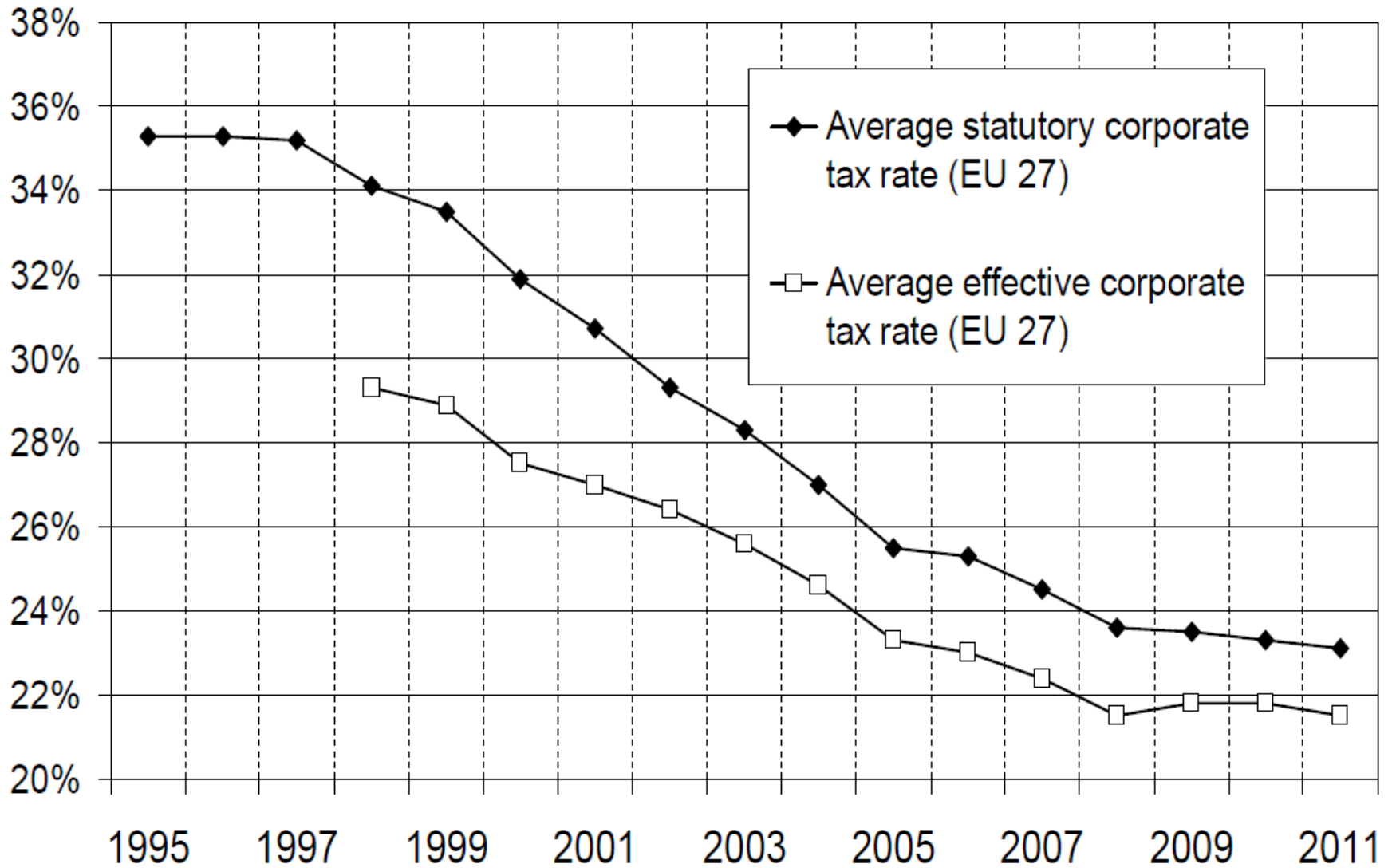
Figure 5

Nominal and Effective Corporate Tax Rates on US Corporate Profits



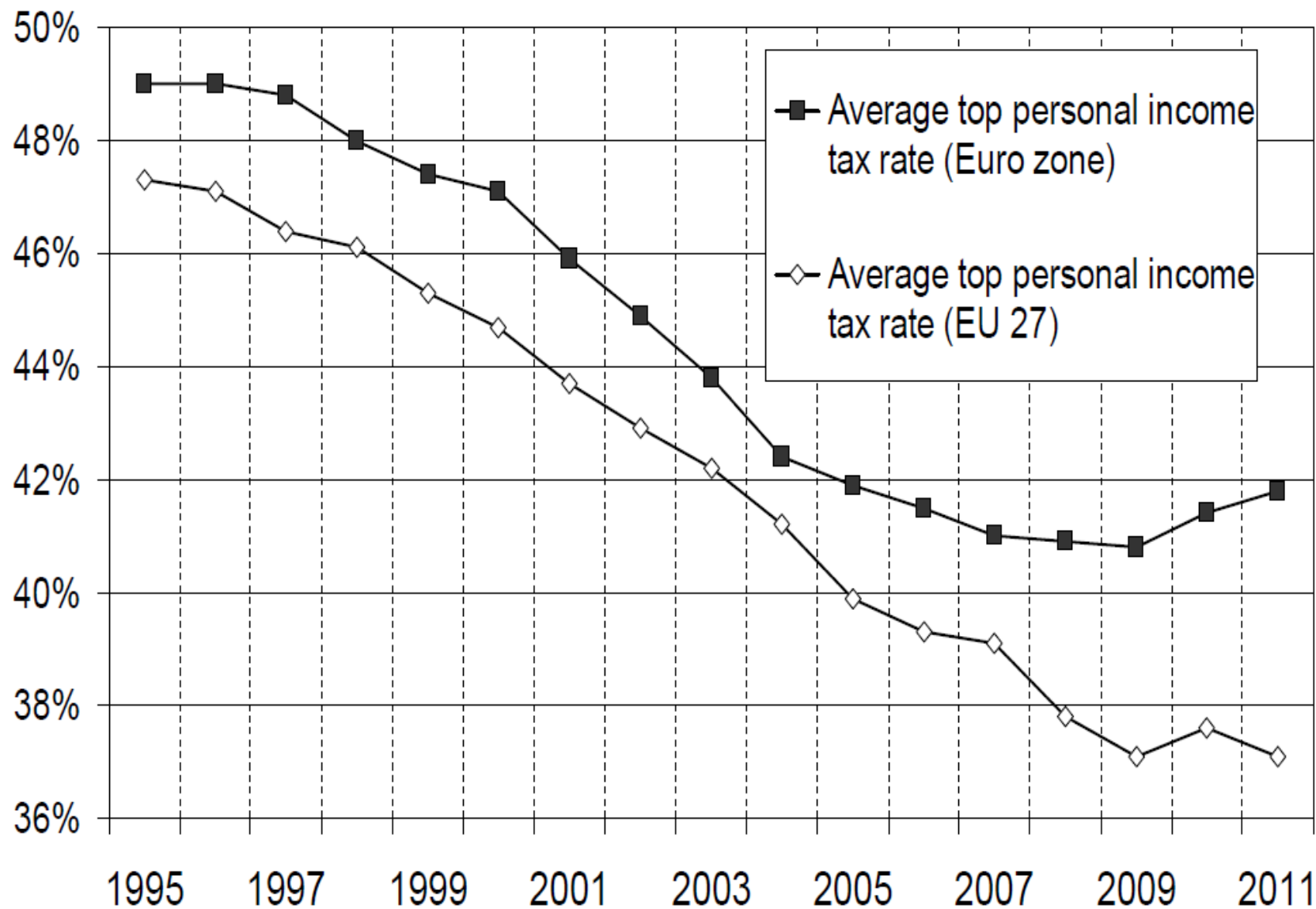
Source: Author's computations using National Income and Product Accounts data. See online Appendix.
Notes: The figure reports decennial averages (for example, 1970-79 is the average for years 1970, 1971 through 1979.) In 2013, over \$100 of corporate profits earned by US residents, on average \$16 is paid in corporate taxes to the US government (federal and states) and \$4 to foreign governments.

Corporate tax competition in the EU



Source: Taxation trends in the EU, Eurostat 2011

Personal income tax competition in the EU



Source: Taxation trends in the EU, Eurostat 2011

- **From now on we assume a closed economy (or perfect international coordination):** not because this is realistic, but because in order to know whether we should coordinate (which is technically not very complicated), we need to know what would be the coordinated optimum; some people believe that even if perfect coordination was possible, we should have zero k tax for purely economic reasons; sometime the same people shift from economic reasons to tax-evasion reasons without being explicit
- In effect, capital mobility & limited coordination raise elasticities of capital supply; see e.g. discussion of income-shifting/tax-avoidance elasticity e_2 in Piketty-Saez-Stantcheva [AEJ 2014](#)
- In the case of perfect mobility with zero international coordination, $e_2 = \infty \rightarrow$ no k tax is possible
- In practice, there are always frictions and asset specificities (e.g. most k cannot move so easily and/or is more valuable in certain territories), so $e_2 < +\infty$

Basic theoretical results on zero capital taxation

- Basic theoretical result = zero optimal capital tax rate = mechanical implication of Atkinson-Stiglitz 1976 no-differential-commodity-tax result to intertemporal consumption
 - = relies on several assumptions: full observability of k income flows + 100% lifecycle wealth (zero inheritance) + perfect capital markets
 - (or infinite horizon/infinite long-run elasticity of capital supply)
- If these assumptions are verified, then the case of zero capital tax is indeed very strong

Basic result 1: without inheritance, and with perfect capital markets, optimal k tax = 0%

- Intuition: if 100% of capital accumulation comes from lifecycle savings, then taxing capital or capital income is equivalent to using differential commodity taxation (current consumption vs future consumption)
- Atkinson-Stiglitz: under fairly general conditions (separable preferences), differential commodity taxation is undesirable, and the optimal tax structure should rely entirely on direct taxation of labor income
- To put it differently: if inequality entirely comes from labor income inequality, then it is useless to tax capital; one should rely entirely on the redistributive taxation of labor income)

- Atkinson-Stiglitz 1976:
 - Model with two periods $t=1$ & $t=2$
 - Individual i gets labor income $y_{Li} = v_i l_i$ at $t=1$ (v_i = wage rate, l_i = labor supply), and chooses how much to consume c_1 and c_2
 - Max $U(c_1, c_2) - V(l)$
- under budget constraint: $c_1 + c_2/(1+r) = y_L$
- Period 1 savings $s = y_L - c_1 (\geq 0)$
 - Period 2 capital income $y_k = (1+r)s = c_2$
 - r = rate of return (= marginal product of capital F_K with production function $F(K, L)$)
- >>> taxing capital income y_k is like taxing the relative price of period 2 consumption c_2

>>> Atkinson-Stiglitz: under separable preferences $U(C_1, C_2) - V(l)$, there is no point taxing capital income; it is more efficient to redistribute income by using solely a labor income tax $t(y_L)$

With non-separable preferences $U(C_1, C_2, l)$, it might make sense to tax less the goods that are more complement with labor supply (say, tax less day care or baby sitters, and tax more vacations); but this requires a lot of information on cross-derivatives

- See A.B. Atkinson and J. Stiglitz, “The design of tax structure: direct vs indirect taxation”, [Journal of Public Economics 1976](#)
- V. Christiansen, « Which Commodity Taxes Should Supplement the Income Tax ? », [Journal of Public Economics 1984](#)
- E. Saez, “The Desirability of Commodity Taxation under Non-Linear Income Taxation and Heterogeneous Tastes”, [Journal of Public Economics 2002](#)
- E. Saez, « Direct vs Indirect Tax Instruments for Redistribution : Short-run vs Long-run », [Journal of Public Economics 2004](#)

Basic result 2: with infinite-horizon dynasties, optimal linear k tax = 0% (=because of infinite elasticity of long run capital supply), but optimal progressive k tax > 0%

- Simple model with capitalists vs workers
- Consider an infinite-horizon, discrete-time economy with a continuum $[0;1]$ of dynasties.
- For simplicity, assume a two-point distribution of wealth. Dynasties can be of one of two types: either they own a large capital stock k_t^A , or they own a low capital stock k_t^B ($k_t^A > k_t^B$). The proportion of high-wealth dynasties is exogenous and equal to λ (and the proportion of low-wealth dynasties is equal to $1-\lambda$), so that the average capital stock in the economy k_t is given by:
 - $k_t = \lambda k_t^A + (1-\lambda)k_t^B$

- Consider first the case $k_t^B=0$. I.e. low-wealth dynasties have zero wealth (the “workers”) and therefore zero capital income. Their only income is labor income, and we assume it is so low that they consume it all (zero savings). High-wealth dynasties are the only dynasties to own wealth and to save. Assume they maximize a standard dynastic utility function:
- $$U_t = \sum_{t \geq 0} U(c_t)/(1+\theta)^t$$

$$(U'(c) > 0, U''(c) < 0)$$
- All dynasties supply exactly one unit of (homogeneous) labor each period. Output per labor unit is given by a standard production function $f(k_t)$ ($f'(k) > 0, f''(k) < 0$), where k_t is the average capital stock per capita of the economy at period t .

- Markets for labor and capital are assumed to be fully competitive, so that the interest rate r_t and wage rate v_t are always equal to the marginal products of capital and labor:
- $r_t = f'(k_t)$
- $v_t = f(k_t) - r_t k_t$
- In such a dynastic capital accumulation model, it is well-known that the long-run steady-state interest rate r^* and the long-run average capital stock k^* are uniquely determined by the utility function and the technology (irrespective of initial conditions): in steady-state, r^* is necessarily equal to θ , and k^* must be such that:
 - $f'(k^*) = r^* = \theta$
 - I.e. $f'(\lambda k_A) = r^* = \theta$

- This result comes directly from the first-order condition:
- $U'(c_t)/U'(c_{t+1}) = (1+r_t)/(1+\theta)$
- I.e. if the interest rate r_t is above the rate of time preference θ , then agents choose to accumulate capital and to postpone their consumption indefinitely ($c_t < c_{t+1} < c_{t+2} < \dots$) and this cannot be a steady-state. Conversely, if the interest rate r_t is below the rate of time preference θ , agents choose to desaccumulate capital (i.e. to borrow) indefinitely and to consume more today ($c_t > c_{t+1} > c_{t+2} > \dots$). This cannot be a steady-state either.
- Now assume we introduce linear redistributive capital taxation into this model. That is, capital income $r_t k_t$ of the capitalists is taxed at tax rate τ (so that the post-tax capital income of the capitalists becomes $(1-\tau)r_t k_t$), and the tax revenues are used to finance a wage subsidy s_t (so that the post-transfer labor income of the workers becomes $v_t + s_t$).
- Note k_τ^* , $k_{A\tau}^* = k_\tau^*/\lambda$ and r_τ^* the resulting steady-state capital stock and pre-tax interest rate. The Golden rule of capital accumulation implies that:
- $(1-\tau) f'(k_\tau^*) = (1-\tau) r_\tau^* = \theta$

- I.e. the capitalists choose to desaccumulate capital until the point where the net interest rate is back to its initial level (i.e. the rate of time preference). **In effect, the long-run elasticity of capital supply is infinite in the infinite-horizon model:** any infinitesimal change in the net interest rate generates a savings response that is unsustainable in the long run, unless the net interest rate returns to its initial level.
- The long run income of the workers y_τ^* will be equal to:
 - $y_\tau^* = v_\tau^* + s_\tau^*$
 - with: $v_\tau^* = f(k_\tau^*) - r_\tau^* k_\tau^*$
 - and: $s_\tau^* = \tau r_\tau^* k_\tau^*$
 - That is:
 - $y_\tau^* = f(k_\tau^*) - (1-\tau) r_\tau^* k_\tau^* = f(k_\tau^*) - \theta k_\tau^*$
 - Question: what is the capital tax rate τ maximizing workers' income $y_\tau^* = f(k_\tau^*) - \theta k_\tau^*$?
 - Answer: τ must be such that $f'(k_\tau^*) = \theta$, i.e. $\tau = 0\%$

- Proposition: The capital tax rate τ maximizing long run workers' welfare is $\tau = 0\%$
 - >>> in effect, even agents with zero capital loose from capital taxation (no matter how small)
 - (= the profit tax is shifted on labor in the very long run)
- But this result requires three strong assumptions: infinite elasticity of capital supply; perfect capital markets; and linear capital taxation: **with progressive tax, middle-class capital accumulation will compensate for the rich decline in k accumulation** (see E. Saez, "Optimal Progressive Capital Income Taxes in the Infinite Horizon Model", [WP 2004](#))
- Most importantly: **the zero capital tax result breaks down whenever the long run elasticity of capital supply is finite**

Four main reasons for taxing capital

- « **Fuzzy frontier argument** »: if one can only observe total income $y = y_L + y_K$, then one needs to use a comprehensive income tax $t(y)$; more generally, if high income-shifting elasticity, then $t(y_L)$ & $t(y_K)$ should not be too different (see [Pirtilla-Selin 2011](#) on dual taxation in Finland and [Yagan et al 2017](#) on US)
- « **Fiscal capacity argument** »: if income flow y is difficult to observe for top wealth holders (family holdings, corporate consumption, etc.: fiscal income reported by billionaires can be very small as compared to their wealth), then one needs to use a wealth tax $t(w)$ in addition to the income tax $t(y)$
- « **Incentive argument** »: by taxing the capital stock rather than the income flow, agents are given incentives to get higher returns (this implicitly requires imperfect k markets)
- « **Meritocratic argument** »: even with full observability of y_L , y_K , w , perfect k markets, etc., inheritance should be taxed as long as the relevant elasticity is finite; imperfect k markets then imply that part of the ideal inheritance tax should be shifted to lifetime k tax; see « A Theory of Optimal Inheritance Taxation », [Econometrica 2013](#) (see also "A Theory of Optimal Capital Taxation", [WP 2012](#) ; [Slides](#))
- See « Rethinking capital and wealth taxation », [PSE 2013](#)

The incentive argument for wealth taxation

- Key argument in favor of taxes on capital stock rather than on flow (i.e. capital tax rather than income tax): they put incentives to get a high return on k (Allais) (see also [Güvener et al 2017](#) for recent model and calibration)
- Other way to put it: if some individuals have high wealth but low income, there's no reason to exempt them from taxation; see e.g. [Fisman et al 2016](#), "Do Americans Want to Tax Capital? Evidence from on-line surveys"
- This implicitly requires to assume imperfect capital markets. I.e. one needs to assume that rate of return r_i is stochastic and depends on individual effort e_i . With perfect k markets everybody should have the same return (full insurance).
- In order to determine optimal wealth tax one also needs to take into account scale economies in portfolio management: higher average rates of return for higher wealth levels

Table 12.1. The growth rate of top global wealth, 1987-2013

<i>Average real growth rate per year (after deduction of inflation)</i>	1987-2013
The top 1/(100 million) highest wealth holders <small>(about 30 adults out of 3 billions in 1980s, and 45 adults out of 4,5 billions in 2010s)</small>	6,8%
The top 1/(20 million) highest wealth holders <small>(about 150 adults out of 3 billions in 1980s, and 225 adults out of 4,5 billions in 2010s)</small>	6,4%
Average world wealth per adult	2,1%
Average world income per adult	1,4%
World adult population	1,9%
World GDP	3,3%

Between 1987 and 2013, the highest global wealth fractiles have grown at 6%-7% per year, vs. 2,1% for average world wealth and 1,4% for average world income. All growth rates are net of inflation (2,3% per year between 1987 and 2013). Sources: see piketty.pse.ens.fr/capital21c.

Table 12.2. The return on the capital endowments of U.S. universities, 1980-2010

<i>Average real annual rate of return (after deduction of inflation and all administrative costs and financial fees)</i>	Période 1980-2010
All universities (850)	8,2%
incl.: Harvard-Yale-Princeton	10,2%
incl.: Endowments higher than 1 billion \$ (60)	8,8%
incl. Endowments between 500 millions and 1 billion \$ (66)	7,8%
incl. Endowments between 100 and 500 millions \$ (226)	7,1%
dont: Endowments less than 100 millions \$ (498)	6,2%

Between 1980 and 2010, U.S. universities earned an average real return of 8,2% on their capital endowments, and all the more so for higher endowments. All returns reported here are net of inflation (2,4% per year between 1980 and 2010) and of all administrative costs and financial fees.

Sources: see piketty.pse.ens.fr/capital21c.

The optimal taxation of inheritance

- Summary of main results from « A Theory of Optimal Inheritance Taxation », Piketty-Saez [Econometrica 2013](#)
- **Dynamic wealth model with stochastic shocks: bequest transmitted to next generation b_{it+1} is a stochastic function of bequest received b_{it} and of shocks on bequest taste parameters, rates of return, wage rates, etc.**
 - steady-state distribution of wealth with two-dimensional inequality of bequests and wages
- Ergodic distribution: there's always a positive probability to move between any two wealth levels across generations
- But the level of mobility and inequality depends upon the structure of shocks and economic parameters (typically inequality rises with $r-g$ and mobility declines with $r-g$)
- On dynamic random shocks models, see also [Course notes on wealth models](#) & Piketty-Zucman, « Wealth & inheritance in the long run », [HID 2015](#) (section 5.4)

- **Result 1: Optimal Inheritance Tax Formula** (macro version, [WP' 12](#))
- Simple formula for optimal bequest tax rate (from the viewpoint of zero receivers) expressed in terms of estimable macro parameters:

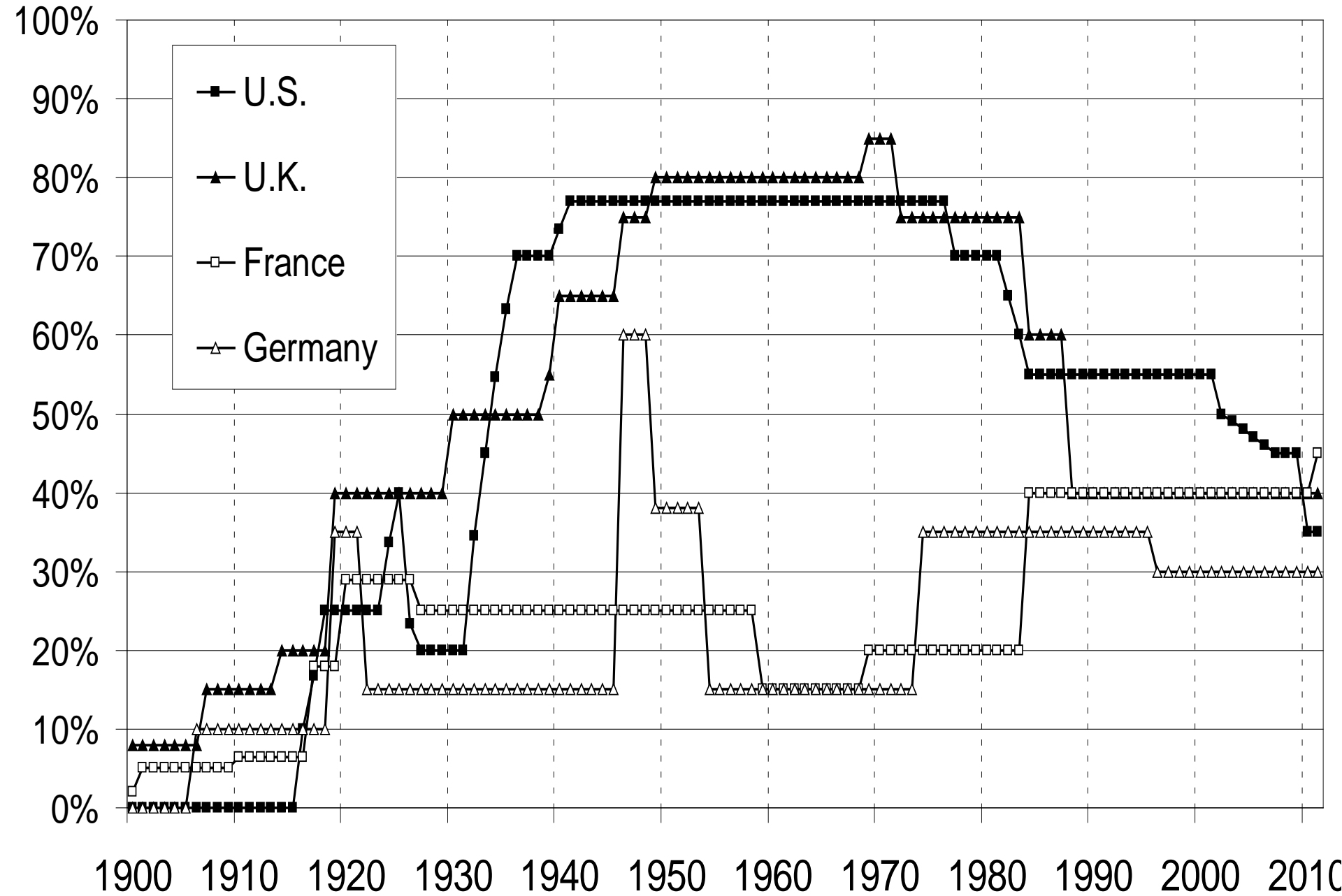
$$\tau_B = (1 - (1 - \alpha - \tau)s_{b0}/b_y) / (1 + e_B + s_{b0})$$

with: b_y = macro bequest flow, e_B = elasticity, s_{b0} = average bequest taste

→ τ_B increases with b_y and decreases with e_B and s_{b0}

- For realistic parameters: $\tau_B = 50\text{-}60\%$ (or more..or less...)
→ **this formula can account for the variety of observed top bequest tax rates (30%-80%)**

Top Inheritance Tax Rates 1900-2011



- Intuition for $\tau_B = (1 - (1-\alpha-\tau)s_{b0}/b_y)/(1+e_B+s_{b0})$
- Meritocratic rawlsian optimum, i.e. social optimum from the viewpoint of zero bequest receivers
- τ_B increases with b_y and decreases with e_B and s_{b0}
- If bequest taste $s_{b0}=0$, then $\tau_B = 1/(1+e_B)$
→ standard revenue-maximizing formula
- If $e_B \rightarrow +\infty$, then $\tau_B \rightarrow 0$: back to zero tax result
- If $e_B=0$, then $\tau_B < 1$ as long as $s_{b0} > 0$
- I.e. zero receivers do not want to tax bequests at 100%, because they themselves want to leave bequests
- **trade-off between taxing rich successors from my cohort vs taxing my own children**

Example 1: $\tau=30\%$, $\alpha=30\%$, $s_{bo}=10\%$, $e_B=0$

- If $b_y=20\%$, then $\tau_B=73\%$ & $\tau_L=22\%$
- If $b_y=15\%$, then $\tau_B=67\%$ & $\tau_L=29\%$
- If $b_y=10\%$, then $\tau_B=55\%$ & $\tau_L=35\%$
- If $b_y=5\%$, then $\tau_B=18\%$ & $\tau_L=42\%$

→ with high bequest flow b_y , zero receivers want to tax inherited wealth at a higher rate than labor income (73% vs 22%); with low bequest flow they want the opposite (18% vs 42%)

Intuition: with low b_y (high g), not much to gain from taxing bequests, and this is bad for my own children

With high b_y (low g), it's the opposite: it's worth taxing bequests, so as to reduce labor taxation and allow zero receivers to leave a bequest

Example 2: $\tau=30\%$, $\alpha=30\%$, $s_{bo}=10\%$, $b_y=15\%$

- If $e_B=0$, then $\tau_B=67\%$ & $\tau_L=29\%$
- If $e_B=0.2$, then $\tau_B=56\%$ & $\tau_L=31\%$
- If $e_B=0.5$, then $\tau_B=46\%$ & $\tau_L=33\%$
- If $e_B=1$, then $\tau_B=35\%$ & $\tau_L=35\%$

→ behavioral responses matter but not hugely as long as the elasticity e_B is reasonable

Kopczuk-Slemrod 2001: $e_B=0.2$ (US)

(French experiments with zero-children savers: $e_B=0.1-0.2$)

- **Optimal Inheritance Tax Formula (micro version, EMA'13)**
- The formula can be rewritten so as to be based solely upon estimable distributional parameters and upon r vs g :
- $\tau_B = (1 - Gb^*/Ry_L^*)/(1+e_B)$

With: b^* = average bequest left by zero-bequest receivers as a fraction of average bequest left

y_L^* = average labor income earned by zero-bequest receivers as a fraction of average labor income

G = generational growth rate, R = generational rate of return

- If $e_B=0$ & $G=R$, then $\tau_B = 1 - b^*/y_L^*$ (**pure distribution effect**)

→ if $b^*=0.5$ and $y_L^*=1$, $\tau_B = 0.5$: if zero receivers have same labor income as rest of the pop and expect to leave 50% of average bequest, then it is optimal from their viewpoint to tax bequests at 50% rate

- If $e_B=0$ & $b^*=y_L^*=1$, then $\tau_B = 1 - G/R$ (**fiscal Golden rule**)

→ if $R \rightarrow +\infty$, $\tau_B \rightarrow 1$: zero receivers want to tax bequest at 100%, even if they plan to leave as much bequest as rest of the pop

Figure 1: Optimal linear inheritance tax rates, by percentile of bequest received

(calibration of optimal tax formulas using 2010 micro data)

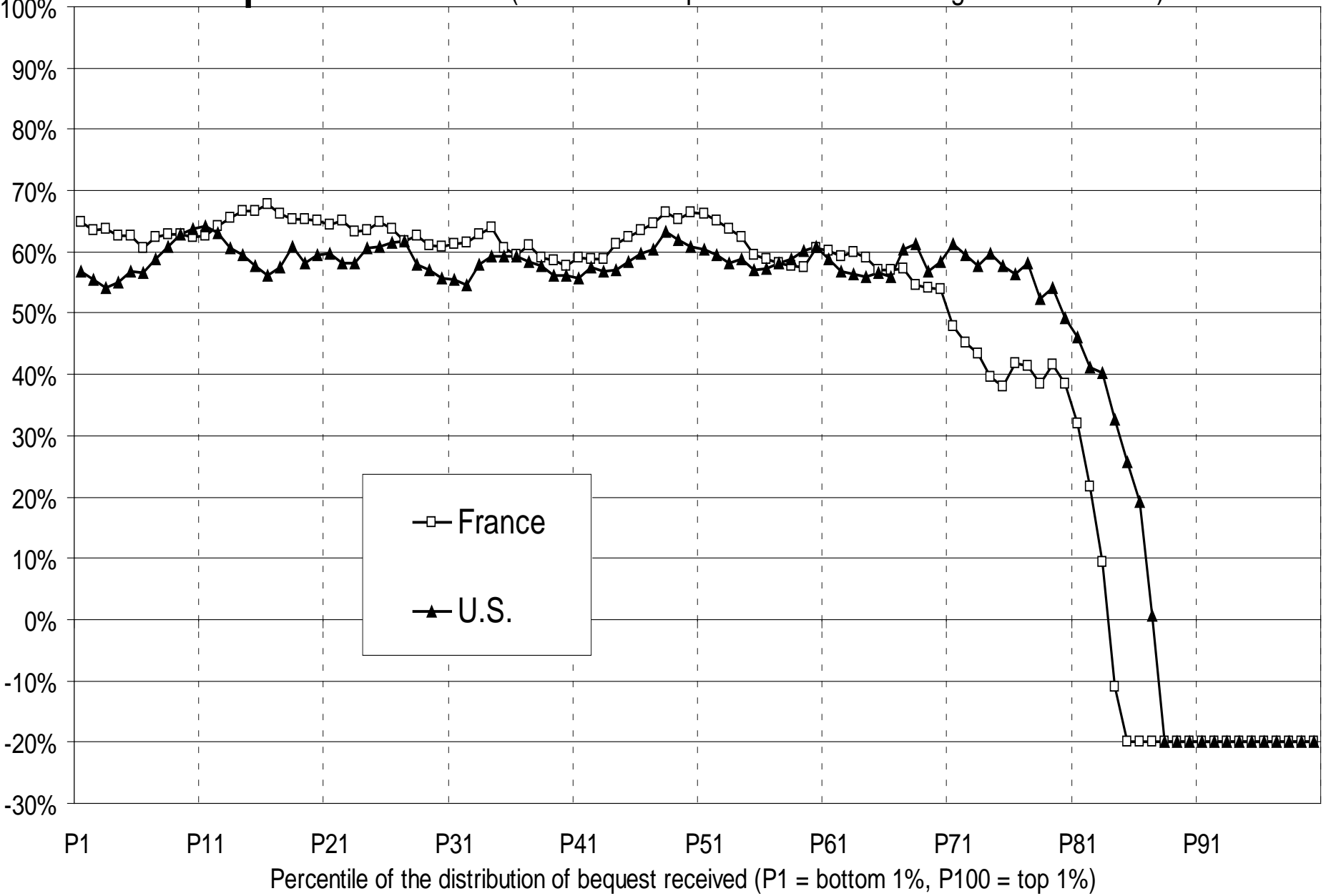
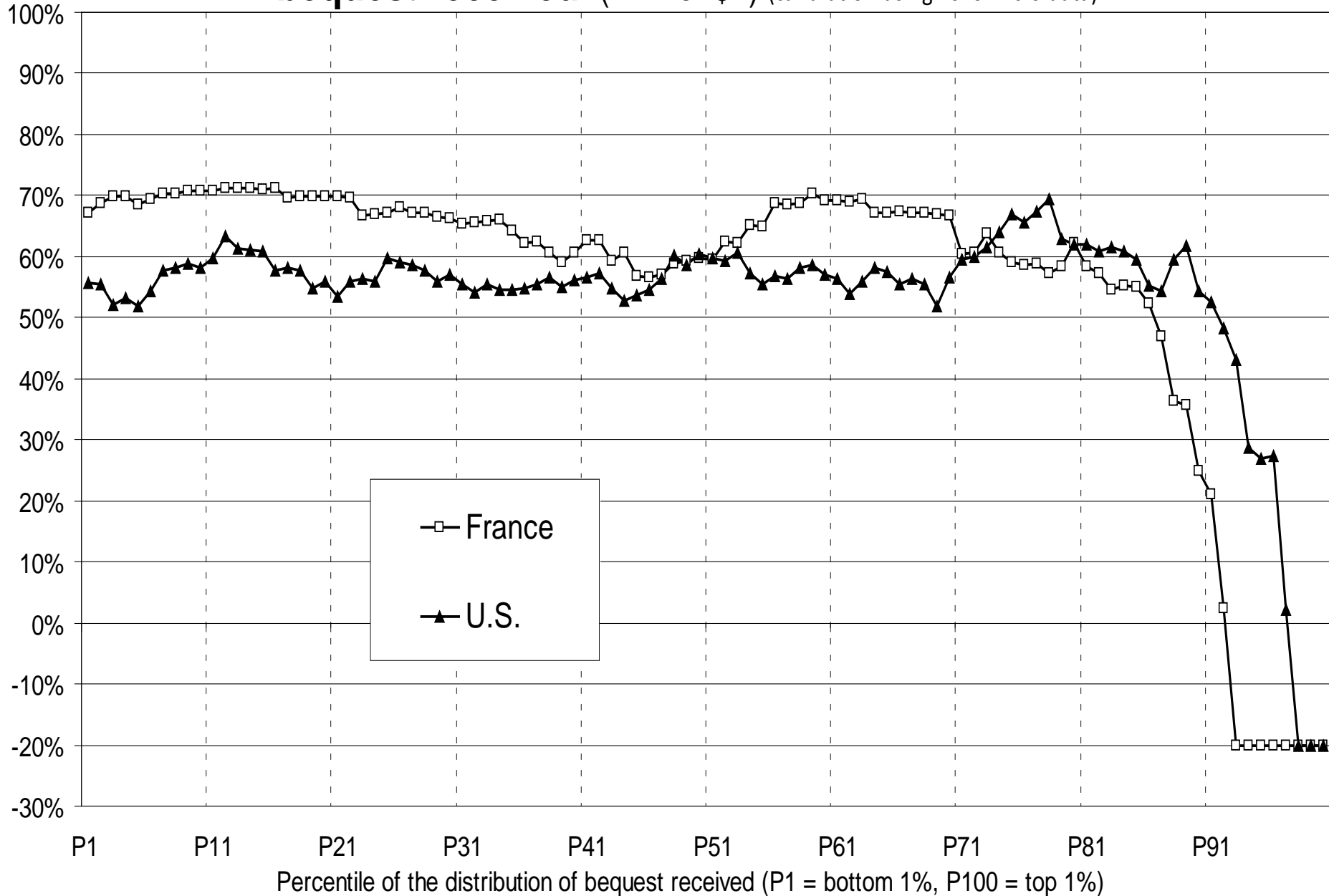


Figure 2: Optimal top inheritance tax rates, by percentile of bequest received (1m€ or \$+) (calibration using 2010 micro data)



- **Result 2: Optimal Capital Tax Mix** (NBER [WP'12](#))
 - **K market imperfections** (e.g. uninsurable idiosyncratic shocks to rates of return) can justify shifting one-off inheritance taxation toward lifetime capital taxation (property tax, K income tax,..)
 - **Intuition:** what matters is capitalized bequest, not raw bequest; but at the time of setting the bequest tax rate, there is a lot of uncertainty about what the rate of return is going to be during the next 30 years → so it is more efficient to split the tax burden
- **this can explain the actual structure & mix of inheritance vs lifetime capital taxation**
- (& why high top inheritance and top capital income tax rates often come together, e.g. US-UK 1930s-1980s)

Equivalence between τ_B and τ_K

- In basic model with perfect markets, tax τ_B on inheritance is equivalent to tax τ_K on annual return r to capital as:

after tax capitalized inheritance $\underline{b}_{ti} = (1 - \tau_B)b_{ti}e^{rH} = b_{ti}e^{(1-\tau_K)rH}$

$$\text{i.e. } \tau_K = -\log(1-\tau_B)/rH$$

- E.g. with $r=5\%$ and $H=30$, $\tau_B=25\% \leftrightarrow \tau_K=19\%$,
 $\tau_B=50\% \leftrightarrow \tau_K=46\%$, $\tau_B=75\% \leftrightarrow \tau_K=92\%$

- This equivalence no longer holds with

(a) tax enforcement constraints, or **(b)** life-cycle savings,

or **(c)** uninsurable risk in $r=r_{ti}$

→ Optimal mix τ_B, τ_K then becomes an interesting question

→ Full formulas are complicated: one needs to find simple sufficient statistics, e.g. unequal wealth growth rates by wealth levels

→ **Much more research is needed on the optimal capital tax mix**

A different view on capital taxation: immaterial capital, broadband and « unique » assets

- The taxation of immaterial capital (intellectual property, patents, etc.) raises very different issues: if copy costs are zero, then the social optimum should involve free use of immaterial capital... except that one needs to put incentives for the production of new ideas
- In practice, mixture of public production of ideas and research with free access (but copyrights for books by public researchers...) and private production with patents: equivalent to temporary property rights or gradual capital tax (20-year patent \approx 5% annual k tax)

- Other problem: capital as usage rights over unique assets
- Typical example: broadband radio spectrum
- Should we auction broadband usage rights forever (permanent private property, which private owners can resell to other users), or every year (temporary property rights, so as to foster reallocation between potential users, \approx 100% capital tax at the end of each year) ?

- [Weyl-Zhang 2016](#) « Ownership of means of production »: if you have full private property over unique assets (broadband, special spots for buildings etc., and more generally all capital assets), then this will lead to monopoly power and insufficient reallocation of usage rights
- On the other hand, annual auctions and public management of entire capital stock is complicated to organize
- Best solution: private property (permanent auctions), but with high wealth tax rates, up to 5-10% per year according to Weyl-Zhang calibration to US housing markets