Lecture 4 - Investment

UCLA - Econ 221 - Fall 2018

François Geerolf

UCLA

October 24, 2018

Outline

Investment?

- After consumption, investment is very important for macroeconomics:
  - in the Solow (1958) neoclassical growth model, investment increases labor productivity.
  - volatility of investment is high = matters for **business cycle fluctuations**.
- Matters both for neoclassical and Keynesian:
  - Neoclassical theory: elasticity of investment with respect to the user cost of capital is high. Cobb and Douglas (1928) famously proposed a unitary elasticity to explain long-run facts: $Y_t = A_t K_t^{\alpha} L_t^{1-\alpha}$. Key for neoclassical growth model.
  - Keynesian theory: effects of monetary policy on investment through the IS curve? (caveat however: which interest rate?)

Overview

- Research very active in the 1990s. Overview of that literature: Caballero (1999).
- Caballero (1999) divides the literature into two camps:
  1. the neoclassical theory emphasizing the importance of the return to capital. However, as Hassett and Hubbard (1996) argued in their 1996 survey on the topic: "**While the neoclassical school may have had the theoretical high ground, empirical implementations of neoclassical models have been generally disappointing**."
  2. the accelerationist theory: only scaling variables. (target value for capital, depending on cash flows, sales, investment is made to reach that target)
- Very good surveys on investment are also provided in Chirinko (1993), and Hassett and Hubbard (1996).

Accelerator Model of investment

- One of the first theories of investment os the accelerator model (Clark (1917)).
- The accelerator model is derived by inverting a simple fixed proportion (Lontief) production function and taking first differences.
- Unable to account for the **serial correlation of investment beyond that of output growth** (that is: a very low serial correlation), this model was soon transformed into the flexible accelerator model:

$$I_t = \sum_{\tau=0}^{n} \beta_\tau \Delta K^*_{t-\tau}$$

where I denotes investment, the β_τ's are distributed lag parameters, and K^* is the desired, as opposed to actual, level of capital.

Jorgenson (1963)'s neoclassical theory of investment intended to remedy this situation. Starting from the optimization problem of a perfectly competitive firm facing no adjustment costs, myopic expectations, and constant returns Cobb-Douglas technology, Jorgenson obtained the static FOC:

$$K = \alpha \frac{Y}{C_k}.$$

where C_k stands for the cost of capital and a is now the share of capital in a simple Cobb-Douglas production function. As with the accelerator model, this model was unable to account for the serial correlation of investment, and so gave way to the flexible neoclassical model of Hall and Jorgenson (1967), where:

$$K^* = \alpha \frac{Y}{C_k},$$

is now used in:

$$I_t = \sum_{\tau=0}^{n} \beta_\tau \Delta K^*_{t-\tau}$$

In this interpretation, the target level of capital depends on the cost of capital.

Neoclassical Model of investment

Jorgenson (1963)'s neoclassical theory of investment. Optimization problemwith constant returns Cobb-Douglas technology:

$$K = \alpha \frac{Y}{C_k}.$$

where C_k stands for the cost of capital and α is now the share of capital in a simple Cobb-Douglas production function. As with the accelerator model, this model was unable to account for the serial correlation of investment, and so gave way to the flexible neoclassical model of Hall and Jorgenson (1967), where:

$$K^* = \alpha \frac{Y}{C_k},$$

is now used in:

$$I_t = \sum_{\tau=0}^{n} \beta_\tau \Delta K^*_{t-\tau}$$

In this interpretation, the target level of capital depends on the cost of capital.

Hamiltonian: Set-up

- Demand for capital, in neoclassical theory given by the rental rate of capital $r_{K,t}$, so that firms solve:

$$\max_{k_t} \int_0^\infty e^{-\rho t} \left(\pi(k_t) - r_{K,t} k_t\right) dt.$$

- The optimal amount of capital is given by: $\boxed{\pi'(k_t) = r_{K,t}}$.
- But most capital is not rented. (and more importantly, we don't like to look at interest rate evidence. asset prices work better) Q-theory:

$$V(k_0) = \max_{i_t} \int_0^\infty e^{-\rho t} \left(\pi(k_t) - p_t i_t\right) dt$$
$$s.t. \quad \dot{k}_t = i_t - \delta k_t.$$

Results

- The profits nets of capital costs of the firm are given by:

$$\Pi(k_t) = \pi(k_t) - p_t i_t.$$

- If $\Pi(k_t) > 0$, firm pumps out cash in period t (repays debt, pays dividends).
- If $\Pi(k_t) < 0$, firm borrows in period t (issues debt, etc.)
- Implicit in this formulation is that the firm can invest more than it is producing in period t.
- In other words, any positive net present value is undertaken.
- This will remain true under the assumption of adjustment costs to capital.
- Hence, everything we'll do today will be referred to as "frictionless".

Hamiltonian I

- Detour: Optimal Control theory in continuous time.
- Consider the classic:

$$\max_{c_t} V(0) = \int_0^T v(k_t, c_t, t)dt$$
$$\text{s.t.} \quad \dot{k}_t = g(k_t, c_t, t), \quad t \in [0, T]$$
$$\text{s.t.} \quad k_0 \text{ given}$$
$$\text{s.t.} \quad k_T \geq 0$$

- T is finite or infinite.
- FOCs are:

$$\frac{\partial H}{\partial c_t} = 0, \quad \frac{\partial H}{\partial k_t} = -\dot{\mu}_t$$
$$\mu_T = 0 \quad \text{or} \quad k_T = 0.$$

- Intuition ?

Hamiltonian

- An intuition for this result can be gained by forming the following "Lagrangian", with a continuum of multipliers μ_t:

$$L = \int_0^T v(k_t, c_t, t)dt + \int_0^T \mu_t \left(g(k_t, c_t, t) - \dot{k}_t \right) dt + \nu k(T).$$

- Since there is then no possible derivation with respect to $\dot{k}_t$, the trick is to integrate by parts:

$$\begin{aligned} -\int_0^T \mu_t \dot{k}_t dt &= -\left[\mu_t k_t\right]_0^T + \int_0^T \dot{\mu}_t k_t dt \\ &= \mu_0 k_0 - \mu_T k_T + \int_0^T \dot{\mu}_t k_t dt \end{aligned}$$

Hamiltonian

- Plugging back:

$$L = \int_0^T v(k_t, c_t, t)dt + \int_0^T \mu_t \left(g(k_t, c_t, t) - \dot{k}_t \right) dt + \nu k(T)$$
$$= \int_0^T \left[v(k_t, c_t, t) + \mu_t g(k_t, c_t, t) \right] dt + \int_0^T \dot{\mu}_t k_t dt + (\nu - \mu_T) k_T.$$

- From these you get:

$$L = \int_0^T \left[v(k_t, c_t, t) + \mu_t g(k_t, c_t, t) \right] dt + \int_0^T \dot{\mu}_t k_t dt + (\nu - \mu_T) k_T.$$

- This gives the First-Order Conditions:

$$\frac{\partial H}{\partial c_t} = 0$$
$$\frac{\partial H}{\partial k_t} = -\dot{\mu}_t$$
$$\mu_T = 0 \quad \text{or} \quad k_T = 0.$$

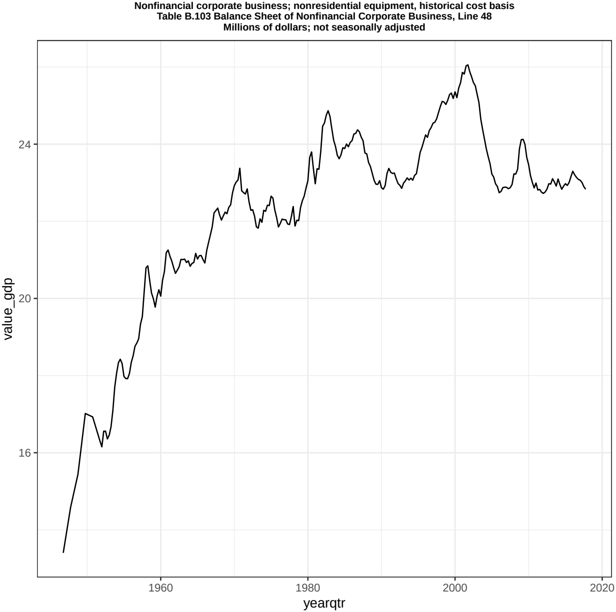
Cobb and Douglas (1928)

- Typical idea: Kaldor facts have:

$$\frac{rK}{Y} = \text{constant}.$$

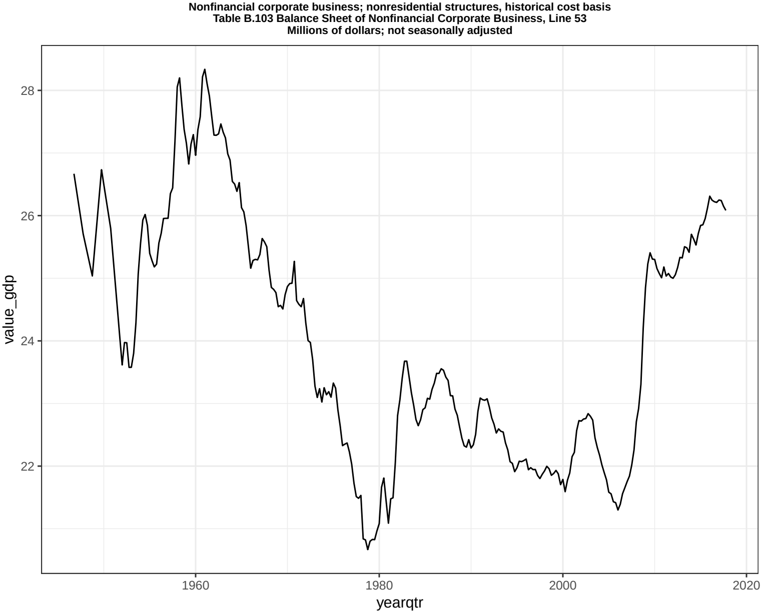
- Therefore, the capital-output ratio's elasticity with respect to permanent changes in the cost of capital is close to minus one?? Look at Acemoglu (2009)'s textbook. All of this does not really rely on a Cobb and Douglas (1928) production function.
- Caballero (1999): "The long run relationship between aggregate capital, output and the cost of capital is not very far from what is implied by the basic **neoclassical model**: in the US, the elasticity of the capital-output ratio with respect to permanent changes in the cost of capital is close to **minus one**."

Equipment



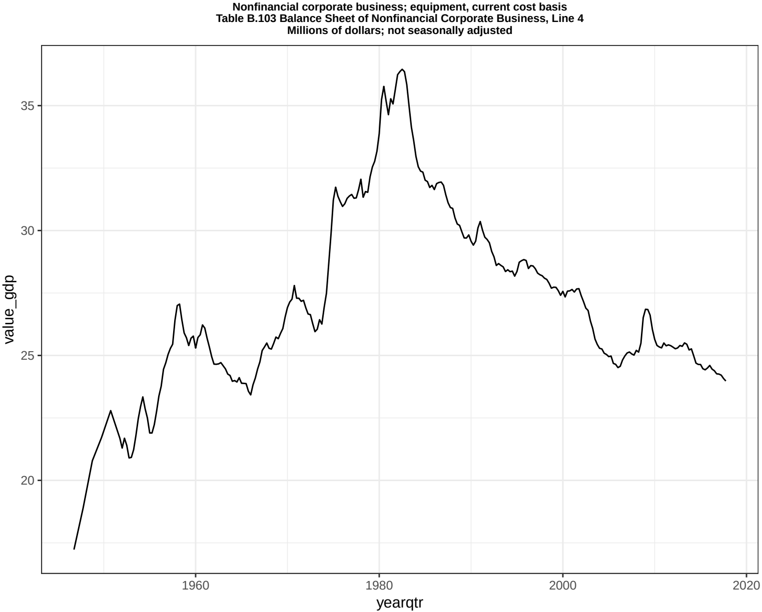
Nonfinancial corporate business; nonresidential equipment, historical cost basis
Table B.103 Balance Sheet of Nonfinancial Corporate Business, Line 48
Millions of dollars; not seasonally adjusted
value_gdp
24
20
16
1960
1980
2000
2020
yearqtr

Structures



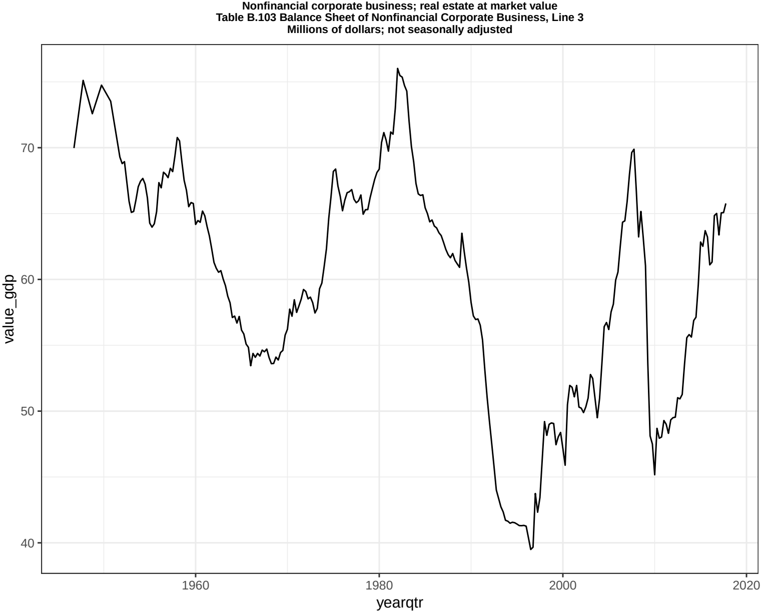
Nonfinancial corporate business; nonresidential structures, historical cost basis
Table B.103 Balance Sheet of Nonfinancial Corporate Business, Line 53
Millions of dollars; not seasonally adjusted
value_gdp
28
26
24
22
1960
1980
2000
2020
yearqtr

Equipment

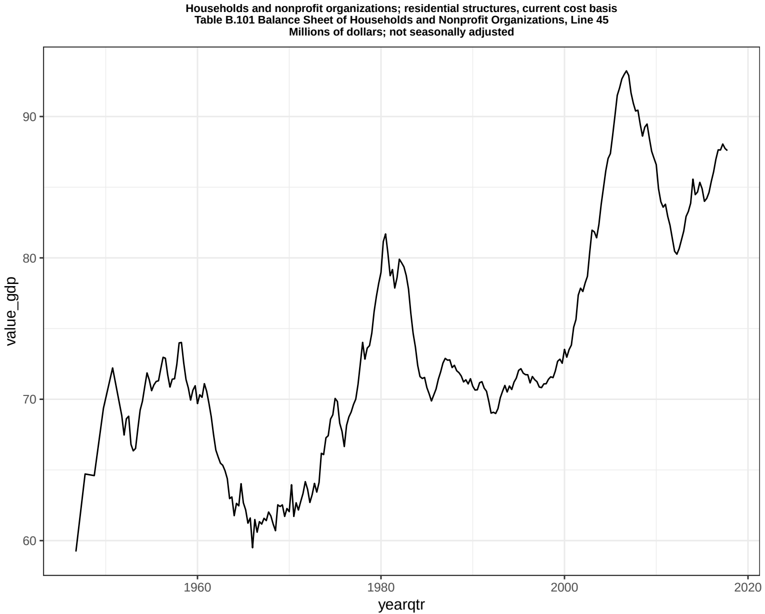


Nonfinancial corporate business; equipment, current cost basis
Table B.103 Balance Sheet of Nonfinancial Corporate Business, Line 4
Millions of dollars; not seasonally adjusted
value_gdp
35
30
25
20
1960
1980
2000
2020
yearqtr

Real estate


Nonfinancial corporate business; real estate at market value
Table B.103 Balance Sheet of Nonfinancial Corporate Business, Line 3
Millions of dollars; not seasonally adjusted
value_gdp
70
60
50
40
1960
1980
2000
2020
yearqtr

Residential structures



1. Theory

2. Macroeconomic Evidence
   - Cobb and Douglas (1928)
   - Piketty and Zucman (2014)

3. Microeconomic Evidence
   - Summers et al. (1981)
   - Shapiro et al. (1986)
   - Fazzari et al. (1988)
   - Cummins et al (1994)
   - Chaney et al. (2012)
   - Yagan (2015)
   - Fuest et al. (2018)

4. Conclusion

Piketty and Zucman (2014)

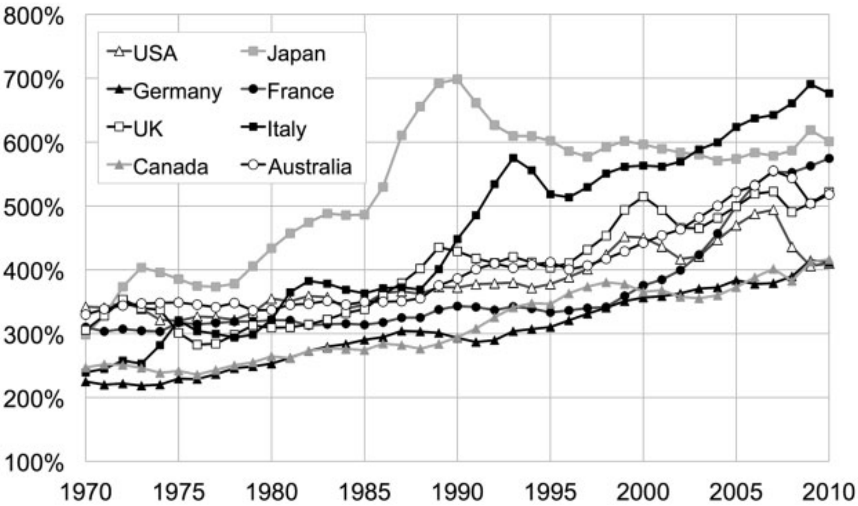


FIGURE I

Private Wealth-National Income Ratios, 1970–2010

Piketty and Zucman (2014)

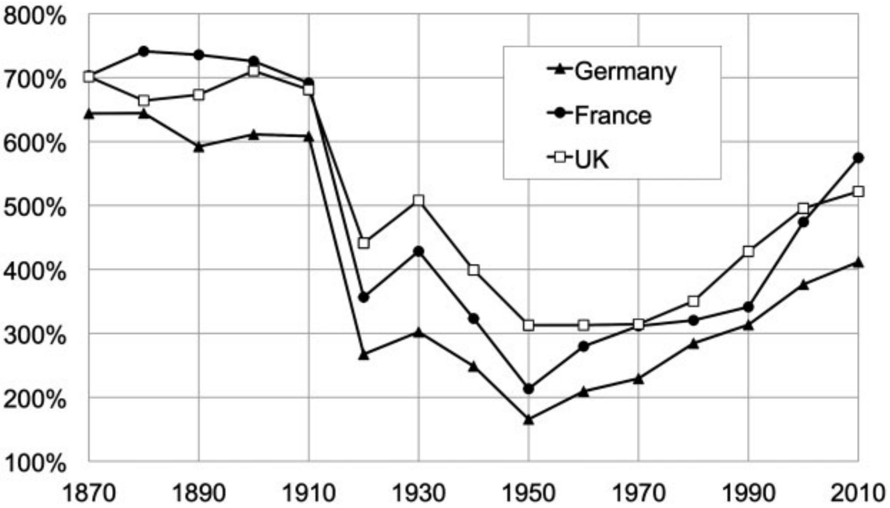


FIGURE II

Private Wealth-National Income Ratios in Europe, 1870–2010

Piketty and Zucman (2014)

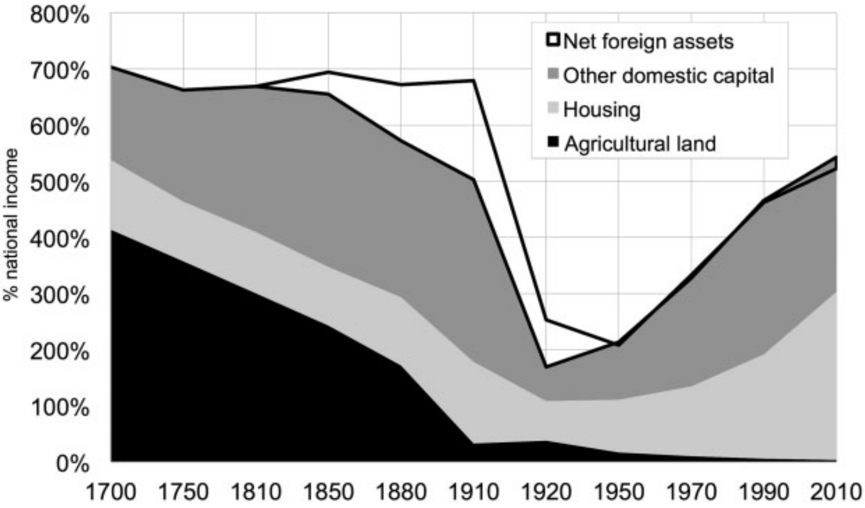


FIGURE III

The Changing Nature of National Wealth: United Kingdom, 1700–2010

Piketty and Zucman (2014)

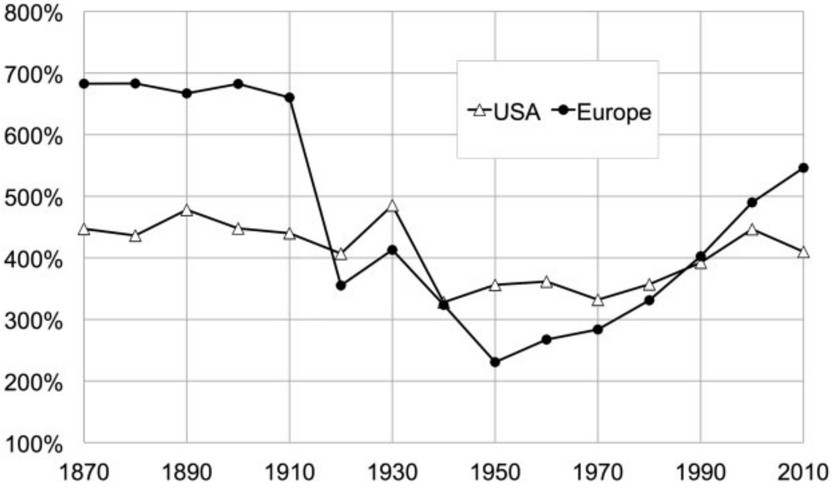


FIGURE IV

Private Wealth-National Income Ratios, 1870–2010: Europe versus United States

Piketty and Zucman (2014)

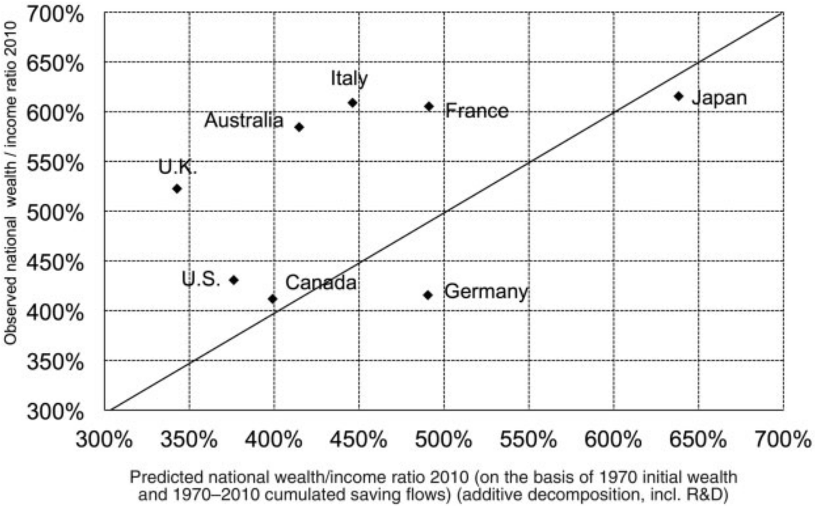


FIGURE VII

Observed versus Predicted National Wealth-National Income Ratios (2010)

Piketty and Zucman (2014)

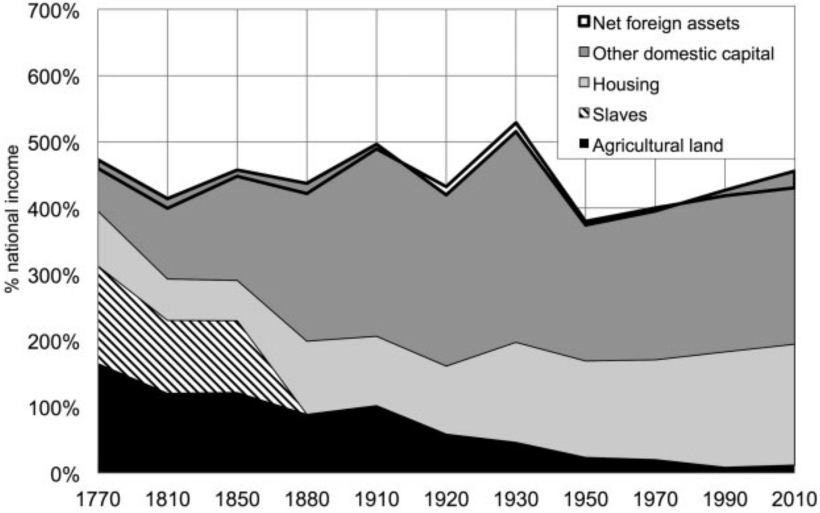


FIGURE X

The Changing Nature of Wealth: United States, 1770–2010

Piketty and Zucman (2014)

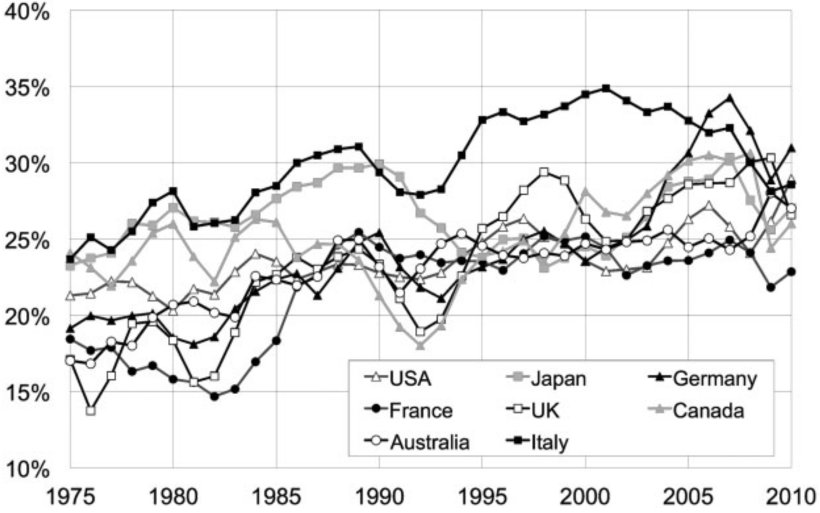


FIGURE XII

Capital Shares in Factor-Price National Income, 1975–2010

Piketty and Zucman (2014)

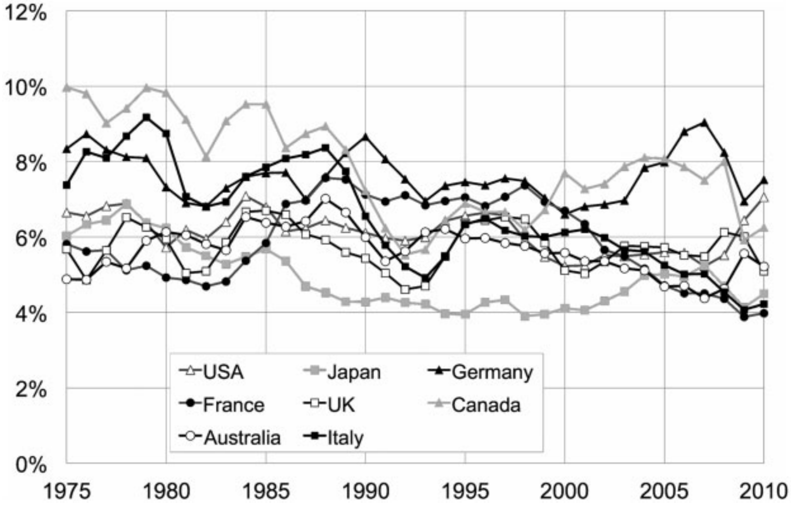


FIGURE XIII

Average Return on Private Wealth, 1975–2010

1. Theory
2. Macroeconomic Evidence
   - Cobb and Douglas (1928)
   - Piketty and Zucman (2014)
3. Microeconomic Evidence
   - Summers et al. (1981)
   - Shapiro et al. (1986)
   - Fazzari et al. (1988)
   - Cummins et al (1994)
   - Chaney et al. (2012)
   - Yagan (2015)
   - Fuest et al. (2018)
4. Conclusion

Summers et al. (1981)

- Summers et al. (1981) assumes a quadratic adjustment costs with constant returns. This yields the following empirical specification:

$$I_t/K_t = c + b\,(q_t - 1) + \epsilon_t.$$

- The coefficient b in this regression is the inverse of the constant term in the cost function that is:

$$D\left(\frac{I}{K}\right) = \frac{1}{2b}\frac{I}{K}.$$

- The results indicate $\hat{b} = 0.031(0.005)$ which is significant, but very low: investment is not very responsive to q.

Results

Table 4. *q* **Investment Equations, 1932–78**[a]

		Independent variable		Summary statistic		
Equation[b]	*Constant*	$q-1$	*Q*	*Rho*	*Standard error of estimate*	*Durbin-Watson*
4-1	0.119 (0.006)	−0.038 (0.019)	...	...	0.039	0.29
4-2	0.096 (0.008)	...	0.026 (0.007)	...	0.036	0.21
4-3	0.104 (0.035)	0.039 (0.016)	...	0.944	0.017	1.27
4-4	0.096 (0.025)	...	0.017 (0.004)	0.923	0.016	1.12
4-5	0.084 (0.033)	0.013 (0.018)	0.015 (0.005)	0.933	0.016	1.11
4-6	0.088 (0.024)	...	0.031 (0.005)	0.922	0.016	1.11
4-7	0.230 (0.039)	−0.106 (0.036)	...	...	0.044	0.43
4-8	0.076 (0.012)	...	0.051 (0.013)	...	0.040	0.34

Source: Estimations by the author.

a. The dependent variable is I/K. Equations in which rho is omitted were estimated without autocorrelation correction. The numbers in parentheses are standard errors.

b. For equation 4-6, the coefficient on Q is the sum of the coefficient on Q and lagged Q. Equations 4-7 and 4-8 were estimated using as instruments the lagged values of the tax variables, θ, c, τ, Z, and ITC.

Results

Table 5. Postwar Q Investment Equations, 1948–78[a]

		Independent variable		Summary statistic		
Equation[b]	*Constant*	*q − 1*	*Q*	*Rho*	*Standard error of estimate*	*Durbin-Watson*
5-1	0.138 (0.002)	0.025 (0.009)	...	...	0.012	0.92
5-2	0.128 (0.003)	...	0.009 (0.003)	...	0.011	0.73
5-3	0.140 (0.004)	0.034 (0.019)	...	0.582	0.011	1.88
5-4	0.127 (0.007)	...	0.015 (0.004)	0.763	0.009	1.97
5-5	0.135 (0.021)	−0.010 (0.026)	0.016 (0.004)	0.721	0.009	1.94
5-6	0.123 (0.012)	...	0.025 (0.005)	0.894	0.008	1.93
5-7	0.098 (0.014)	0.042 (0.015)	...	...	0.012	0.77
5-8	0.124 (0.004)	...	0.015 (0.005)	...	0.011	0.58

Source: Estimations by the author.

a. The dependent variable is I/K. Equations in which rho is omitted were estimated without autocorrelation correction. The numbers in parentheses are standard errors.

b. For equation 5-6, the coefficient on Q is the sum of the coefficient on Q and lagged Q. Equations 5-7 and 5-8 were estimated using as instruments the lagged values of the tax variables, θ, c, τ, Z, and ITC.

Shapiro et al. (1986) Set-up

- Shapiro et al. (1986): "The theory behind the accelerator model is akin to he man-on-the-street view that firms have little incentive to invest when current prospects for selling the output produced by the new capital are relatively poor."
- According to Shapiro et al. (1986): "Neo-Keynesians should not, however, find comfort in this embarrassment of neoclassical theory. The textbook IS-LM model is also inconsistent with the empirical finding that output shocks rather than cost-of-capital shocks determine investment. If the interest rate does not affect investment, then the IS curve is vertical, and there is no role for the Keynesian transmission mechanism from money to output."
- In his footnote 1, Shapiro et al. (1986) further explains that "one could argue that the Keynesian transmission mechanism could be resurrected by **letting the interest rate channel work through housing and consumer durables** rather than fixed investment."

Shapiro et al. (1986)Set-up

- Economists often recommend increasing investment by reducing the cost of capital through tax incentives such as accelrator depreciation and the investment tax credit.
- Anyone making such recommendations should be able to explain why output shocks seems so much important in investment dynamics than price shocks.
- The nation's best-selling macroeconomics text includes the following passage:

  > ***At least on evidence through 1979; it seems that the cost of capital empirically does not much affect investment and that accordingly the simple accelerator model does as well as the neoclassical model at explaining investment.***

Results

Table 1. Correlation Matrix and Standard Deviations of the Data, 1955:1–1985:3[a]

Item	*Investment*	*Output*	*Price of capital*	*Discount rate*	*Labor*	*Productivity shock, Cobb-Douglas*[b]	*Productivity shock, CES*[c]
Investment	1.0						
Output	0.61	1.0					
Price of capital	0.07	−0.02	1.0				
Discount rate	−0.01	−0.03	0.13	1.0			
Labor	0.70	0.73	0.17	0.10	1.0		
Productivity shock, Cobb-Douglas	0.42	0.87	−0.15	−0.13	0.32	1.0	
Productivity shock, CES	0.33	0.79	−0.19	−0.15	0.16	0.98	1.0
Standard deviation	2.0	6.6	0.014	0.006	0.80	0.010	0.009
Coefficient of variation	2.9	1.7	. . .[d]	0.006	3.1	2.3	2.0

Source: Author's calculations. For definitions and sources of the data, see text and appendix.

a. All variables are expressed as first differences, except the discount rate. Productivity shocks are the residuals from equation 4.

b. ρ, which parameterizes the elasticity of substitution in equation 4, equals zero.

c. Constant elasticity of substitution, where ρ equals -0.4 in equation 4.

d. Mean value approximately zero.

Results

Labor and output useful for forecasting investment.

Table 3. Tests of Granger Causality for Unrestricted Vector Autoregressions, 1955:1–1985:3[a]

Marginal significance for test that variable in row does not Granger cause variable in column[b]

Variable	*Invest-ment*	*Output*	*Price of capital*	*Discount rate*	*Labor*
Investment	0.35	0.77	0.15	>0.99	0.81
Output	0.05	0.35	0.10	0.88	0.40
Price of capital	0.36	0.04	0.15	0.04	0.01
Discount rate	0.59	0.90	0.28	<0.01	0.38
Labor	0.02	0.10	0.43	0.68	0.07
All[c]	<0.01	0.03	0.07	<0.01	<0.01

Source: Author's calculations. See text description.

a. All variables are expressed as first differences, except the discount rate. Each variable is regressed on the constant and two lagged values of all five variables.

b. The numbers in the table give the significance level at which one can reject the hypothesis that two lags of the item in the row are not useful, given the other variables, in forecasting the variable in the column.

c. Significance for the test that none of the lagged variables forecasts the variable in the column.

Blanchard's discussion

- "The discrepancy between theory and empirical work is perhaps nowhere in macroeconomics so obvious as in the case of the aggregate investment function."
- The theory from which the neoclassical investment function was initially derived implies that one should be able to specify the model equally well whether using only factor prices or using output and the user cost of capital. We all know that this is not the case.
- It is very hard to make sense of the distributed lag of output on investment.
- Finally, it is well known that to get the user cost to appear at all in the investment equation,one has to display more than the usual amount of econometric ingenuity, resorting most of the time to choosing a specification that simply forces the effect to be there.

1. Theory

2. Macroeconomic Evidence
   - Cobb and Douglas (1928)
   - Piketty and Zucman (2014)

3. Microeconomic Evidence
   - Summers et al. (1981)
   - Shapiro et al. (1986)
   - Fazzari et al. (1988)
   - Cummins et al (1994)
   - Chaney et al. (2012)
   - Yagan (2015)
   - Fuest et al. (2018)

4. Conclusion

Fazzari et al. (1988) Methodology

- Models with some forms of financial friction imply that internal funds are cheaper than external funds, i.e. firms will tend to rely on retained earnings to fund investment before they turn to external funds (bonds, loans or equity). If that is the case, perhaps it is not surprising that investment increases with higher cash flow or retained earnings.
- The problem with a simple regression of investment on cash flow is that cash flow may contain information about future profitability. This is likely to be true both in the cross section. The idea of FHP is similar to that of Zeldes for households: split the sample into firms that are likely to be constrained and firms that are likely to be unconstrained.

Methodology

- If cash flow is a proxy for profitability, it should matter for both groups identically. But if financial frictions are important, the first group should be more sensitive to cash flows.
- FHP divide firms based on the size of dividends distributed (i.e. distributed earnings vs. retained earnings). The **coefficient on cash flow is 0.230** (0.010) for the **high dividend firms** and 0.461 (0.027) for the low dividend one. The hypothesis that it is the same is strongly rejected. The empirical support for large effects of cash flow on firms and financial frictions is very strong.

Results

Table 1. Sources of Funds, by Asset Class, U.S. Manufacturing Firms, 1970–84

	Source of funds (percent of total)[a]					
Firm size	*Short-term bank debt*	*Long-term bank debt*	*Other long-term debt*	*Retained earnings*	*Percentage of long-term debt from banks*	*Average retention ratio*
All firms	0.6	8.4	19.9	71.1	29.6	0.60
Asset class						
Under $10 million	5.1	12.8	6.2	75.9	67.3	0.79
$10–50 million	5.9	17.4	6.9	69.8	71.6	0.76
$50–100 million	3.1	12.9	5.3	78.7	71.0	0.68
$100–250 million	−0.2	13.3	12.0	74.9	52.4	0.63
$250 million–$1 billion	−2.3	10.6	15.4	76.3	40.8	0.56
Over $1 billion	−0.6	4.8	27.9	67.9	14.7	0.52

Source: Authors' calculations based on data taken from U.S. Department of Commerce, Bureau of the Census, *Quarterly Financial Reports of Manufacturing, Mining, and Trade Corporations*, various issues. The data underlying the calculations are expressed in 1982 dollars.

a. Funds raised from new equity issues are excluded from the calculations.

Descriptive stats

Table 2. Summary Statistics: Sample of Manufacturing Firms, 1970–84

Statistic	Category of firm: *Class 1*[a]	*Class 2*[b]	*Class 3*[c]
Number of firms	49	39	334
Average retention ratio	0.94	0.83	0.58
Percent of years with positive dividends	33	83	98
Average real sales growth (percent per year)	13.7	8.7	4.6
Average investment-capital ratio	0.26	0.18	0.12
Average cash flow–capital ratio	0.30	0.26	0.21
Average correlations of cash flow with investment (deviations from trend)[d]	0.92	0.82	0.20
Average of firm standard deviations of investment-capital ratios	0.17	0.09	0.06
Average of firm standard deviations of cash flow–capital ratios	0.20	0.09	0.06
Capital stock (millions of 1982 dollars)			
Average capital stock, 1970	100.6	289.7	1,270.0
Median capital stock, 1970	27.1	54.2	401.6
Average capital stock, 1984	320.0	653.4	2,190.6
Median capital stock, 1984	94.9	192.5	480.8

Source: Authors' calculations based on samples selected from the Value Line data base. See Appendix B.
a. Firms with dividend-income ratios of less than 0.1 for at least 10 years.
b. Firms with dividend-income ratios greater than 0.1 but less than 0.2 for at least 10 years.
c. Firms with dividend-income ratios greater than 0.2.
d. Estimated from time series constructed by aggregating the sample data within each category.

Results

Table 3. New Share Issues, Tobin's q, and Debt Statistics for Manufacturing Firms, 1970–84

Item	*Class 1*	*Class 2*	*Class 3*
Average percentage of years with new share issues	28	19	10
Average value of share issues as a percentage of cash flow	23	13	8
Average annual q values[a]	3.8	2.4	1.6
	(0.4)	(0.2)	(0.1)
Median q values	1.6	1.4	1.0
Average difference in q values between periods of new share issues and periods of no new share issues[a]	1.6	0.9	0.2
	(0.8)	(0.4)	(0.1)
Average ratio of debt to capital stock	0.57	0.52	0.33
Average ratio of interest payments to sum of interest payments plus cash flows	0.27	0.21	0.17
Correlation of the earnings-to-capital ratio and the change in total debt-to-capital ratio (averaged over firms)	0.23	0.15	0.09

Source: Same as table 2.
a. The standard error of the mean appears in parentheses.

Results

Table 4. Effects of Q and Cash Flow on Investment, Various Periods, 1970–84[a]

Independent variable and summary statistic	*Class 1*	*Class 2*	*Class 3*
		1970–75	
Q_{it}	−0.0010	0.0072	0.0014
	(0.0004)	(0.0017)	(0.0004)
$(CF/K)_{it}$	0.670	0.349	0.254
	(0.044)	(0.075)	(0.022)
$\bar{R}^2$	0.55	0.19	0.13
		1970–79	
Q_{it}	0.0002	0.0060	0.0020
	(0.0004)	(0.0011)	(0.0003)
$(CF/K)_{it}$	0.540	0.313	0.185
	(0.036)	(0.054)	(0.013)
$\bar{R}^2$	0.47	0.20	0.14
		1970–84	
Q_{it}	0.0008	0.0046	0.0020
	(0.0004)	(0.0009)	(0.0003)
$(CF/K)_{it}$	0.461	0.363	0.230
	(0.027)	(0.039)	(0.010)
$\bar{R}^2$	0.46	0.28	0.19

Source: Authors' estimates of equation 3 based on a sample of firm data from Value Line data base. See text and Appendix B.

a. The dependent variable is the investment-capital ratio $(I/K)_{it}$, where I is investment in plant and equipment and K is beginning-of-period capital stock. Independent variables are defined as follows: Q is the sum of the value of equity and debt less the value of inventories, divided by the replacement cost of the capital stock adjusted for corporate and personal taxes (see Appendix B); $(CF/K)_{it}$ is the cash flow–capital ratio. The equations were estimated using fixed firm and year effects (not reported). Standard errors appear in parentheses.

Cummins et al. (1994): Introduction / Motivation

- Cummins et al. (1994): "That is, not only have models emphasizing the net return to investing been defeated in forecasting "horse races" by ad hoc models, but, more important, structural variables are frequently found to be economically or statistically insignificant."

Methodology

- Instrument q using changes in the tax code. The idea is that changes in taxes can have large effects on a firms valuation and will differ across industries depending on capital intensity. So using changes in the tax code, they estimate a $\hat{b}$ close to 0.5 on firm level data (Compustat), which implies that the adjustment costs are more reasonable, around 4% of capital. However, it is unclear how much this result carries over to aggregate investment:
    1. To the extent that the supply of investment goods is not infinitely elastic, the effect of an increased demand for capital may be mostly to raise the price of investment goods.
    2. the R^2 of the regressions are quite low, i.e. q still explains a small fraction of investment at the firm level. In fact, the R^2 increase significantly once we add cash flow or other current variables (current profits, current sales) as a right hand side variable, the fit improves markedly.

Robert Hall's discussion

- Instrument q using changes in the tax code. The idea is that changes in taxes can have large effects on a firms valuation and will differ across industries depending on capital intensity. So using changes in the tax code, they estimate a $\hat{b}$ close to 0.5 on firm level data (Compustat), which implies that the adjustment costs are more reasonable, around 4% of capital. However, it is unclear how much this result carries over to aggregate investment:
    1. To the extent that the supply of investment goods is not infinitely elastic, the effect of an increased demand for capital may be mostly to raise the price of investment goods.
    2. the R^2 of the regressions are quite low, i.e. q still explains a small fraction of investment at the firm level. In fact, the R^2 increase significantly once we add cash flow or other current variables (current profits, current sales) as a right hand side variable, the fit improves markedly.

Caballero's discussion

- Like so many other papers in the investment literature, this one starts by **summarizing the empirical failure of models that emphasize the role of "price" variables in investment equations and by listing the standard culprits** (simultaneity, error in variables, and so forth). Unlike many others, it concludes on a very positive note. By isolating the "exogenous" cross-sectional elements of episodes covering important tax reforms, the authors claim to have eluded the standard problems and found evidence of a large short-run response of investment to price incentives.

Chaney et al. (2012)

Abstract: What is the impact of real estate prices on corporate investment? In the presence of financing frictions, firms use pledgeable assets as collateral to finance new projects. Through this collateral channel, shocks to the value of real estate can have a large impact on aggregate investment. To compute the sensitivity of investment to collateral value, we use **local variations in real estate prices** as **shocks** to the collateral value of firms that own real estate. Over the 1993 – 2007 period, the **representative US corporation invests \$0.06 out of each \$1 of collateral**.

Empirical Strategy

- Follows strategy of Mian et al. (2013) and Mian and Sufi (2014) applied to consumption.
- They run the following reduced form first-stage regression:

$$P_t^l = \alpha^l + \delta_t + \gamma \cdot Elasticity^l \times IR_t + u_t^l.$$

where t denote time subscripts and l denote MSA-subscripts. IR_t is the long term interest rate.

- They use this IV to estimate the following second-stage:

$$INV_{it}^l = \alpha_i + \delta_t + \beta \cdot REValue_{it} + \gamma P_t^l + \ldots\ldots \sum_k \kappa_k \cdot X_k^i \times P_t^l + controls_{it} + \epsilon_{it}$$

where i denotes firm subscripts.

First-Stage Regression

TABLE 3—FIRST-STAGE REGRESSION: THE IMPACT OF LOCAL HOUSING SUPPLY ELASTICITY ON HOUSING PRICES

	MSA Residential Prices		MSA Office Prices	
	(1)	(2)	(3)	(4)
Local housing supply elasticity mortgage rate	0.028***		0.036***	
	(6.3)		(5)	
First quartile of elasticity mortgage rate		−0.064***		−0.066***
		(−8.9)		(−5.1)
Second quartile of elasticity mortgage rate		−0.046***		−0.033**
		(−6)		(−2)
Third quartile of elasticity mortgage rate		−0.014**		−0.0097
		(−2.2)		(−0.41)
Year dummies	Yes	Yes	Yes	Yes
MSA fixed effect	Yes	Yes	Yes	Yes
Observations	1,358	1,358	804	804
Adjusted R^2	0.94	0.94	0.84	0.84

Second-Stage Regression

TABLE 5—REAL ESTATE PRICES AND INVESTMENT BEHAVIOR

	Capital expenditure							
	(OLS)	(OLS)	(OLS)	(OLS)	(OLS)	(IV)	(OLS)	(IV)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RE Value (State Res. Prices)	0.074***	0.065***	0.052***					
	(15)	(13)	(11)					
RE Value (MSA Res. Prices)				0.053***				
				(11)				
RE Value (MSA O. Prices)					0.06***	0.062***		
					(8.9)	(5.5)		
RE OWNER × MSA O. Prices							0.21***	0.44***
							(3.3)	(2.75)
State Res. Prices	−0.11*	−0.91**	−0.46					
	(−1.8)	(−2)	(−1.2)					
MSA Res. Prices				−0.58				
				(−1.3)				
MSA O. Prices					0.25	0.22	0.062	0.2
					(0.27)	(0.09)	(0.065)	(0.075)
Cash			0.027***	0.027***	0.026***	0.026***	0.026***	0.026***
			(8.4)	(8.9)	(7.5)	(3.8)	(7.5)	(4.4)
Market/Book			0.068***	0.068***	0.071***	0.07***	0.072***	0.071***
			(20)	(20)	(19)	(10.1)	(19)	(11.3)
Init. Controls × State Res. Prices	No	Yes	Yes	No	No	No	No	No
Init. Controls × MSA Res. Prices	No	No	No	Yes	No	No	No	No
Init. Controls × MSA Off. Prices	No	No	No	No	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	27,201	27,026	24,167	22,894	17,805	17,586	18,031	17,731
Adjusted R^2	0.28	0.29	0.33	0.33	0.33	0.33	0.33	0.33

Robustness

Table 6—Real Estate Prices and Investment Behavior: Robustness Checks

	Before 1999 (1)	After 2000 (2)	Large MSAs small firms (3)	Δ(PPE) − Δ(RE) (4)	3-years mean capex (5)	Ind. − adj. capex (6)	Unrestricted sample (7)	10K info (8)
RE Value	0.08***	0.078***	0.058***	0.03***	0.088***	0.061***		
(MSA O. Prices)	(6.1)	(5.6)	(5.7)	(4.1)	(12)	(9.2)		
RE OWNER × MSA O. Prices							0.23***	0.17***
							(2.9)	(3.2)
MSA O. Prices	−1.1	0.81	0.12	−0.56	−0.72	0.33	0.99	2.9
	(−0.98)	(1)	(0.21)	(−0.58)	(−0.36)	(0.37)	(0.66)	(1.6)
Cash	0.029***	0.02***	0.022***	0.022***	0.042***	0.025***	0.016***	0.017***
	(5.5)	(3.6)	(4.7)	(6.8)	(12)	(7.3)	(5.5)	(5.1)
Market/Book	0.079***	0.058***	0.061***	0.061***	0.069***	0.068***	0.087***	0.069***
	(15)	(8.5)	(12)	(18)	(17)	(18)	(25)	(21)
Init. controls × MSA O. Prices	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	11,440	6,365	9,282	15,691	14,384	17,782	19,886	17,558
Adjusted R^2	0.37	0.32	0.28	0.19	0.49	0.27	0.33	0.28

Yagan (2015)

Abstract: This paper tests whether the 2003 dividend tax cut—one of the largest reforms ever to a US capital tax rate—stimulated corporate investment and increased labor earnings, using a quasi-experimental design and US corporate tax returns from years 1996–2008. **I estimate that the tax cut caused zero change in corporate investment and employee compensation**. Economically, the statistical precision challenges leading estimates of the cost-of-capital elasticity of investment, or undermines models in which dividend tax reforms affect the cost of capital. Either way, it may be difficult to implement an alternative dividend tax cut that has substantially larger near- term effects.

Yagan (2015)

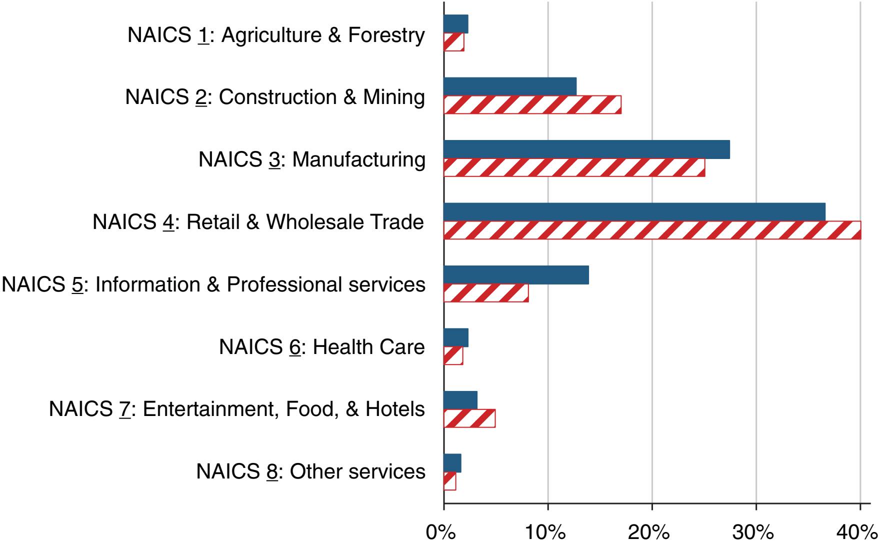
- The Jobs and Growth Tax Relief Reconciliation Act of 2003 reduced the top federal tax rate on individual dividend income in the United States from **38.6 % to 15** %.
- Difference in difference:

$$INV_{it} = \alpha_1 CCORP_{i,t-2} + \alpha_2 CCORP_{i,t-2} \times POST_t + \mathbf{X}_{i,t-2}\beta + \mathbf{YEAR_t}\gamma.$$

- Real corporate outcomes are too cyclical to distinguish tax effects from business cycle effects.
- Aggregate investment rose 31 percent in the five years after the tax cut, but that increase could have been driven by secular emergence from the early 2000s recession.
- C-corporations and S-corporations face similar tax rates except that C-corporations are subject to dividend taxation while S-corporations are not.
- This paper uses S-corporations (not directly affected by the dividend tax cut) as a control group for C-corporations (directly affected) over time.

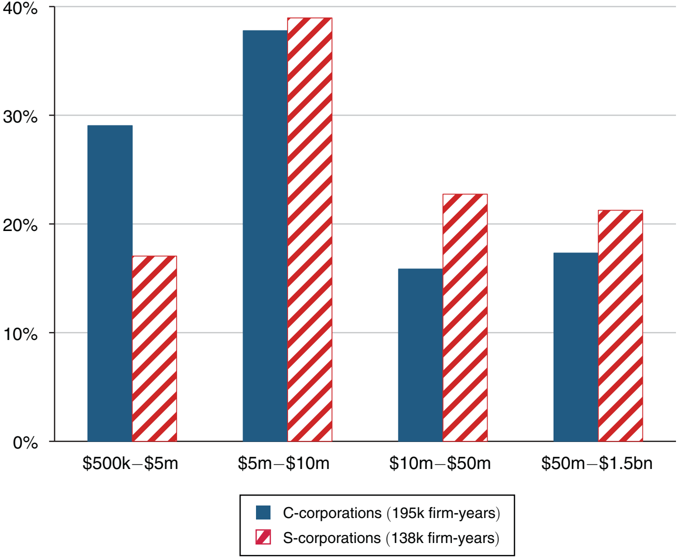
Yagan (2015)

Panel A. Industry



Yagan (2015)

Panel B. Size (lagged revenue)



Effects of the 2003 Dividend Tax Cut

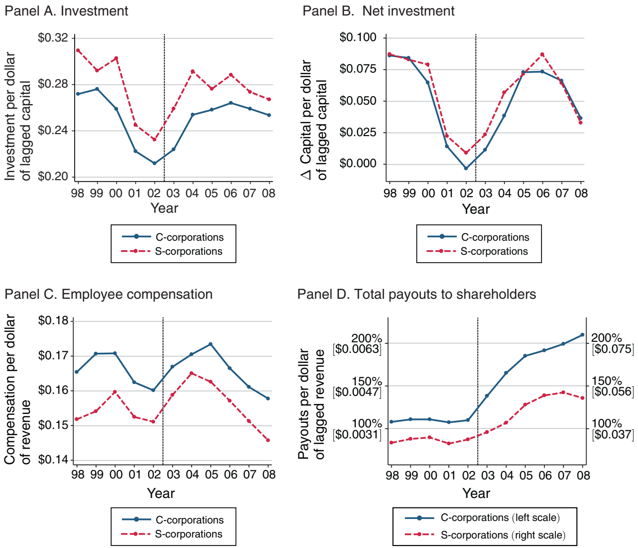
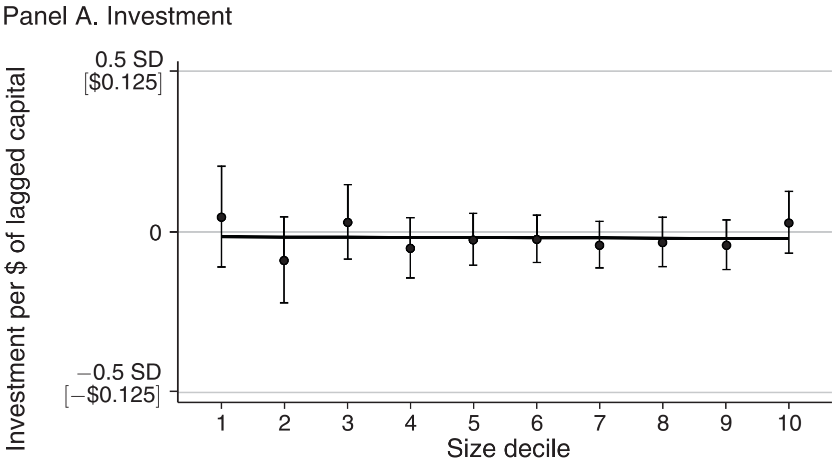
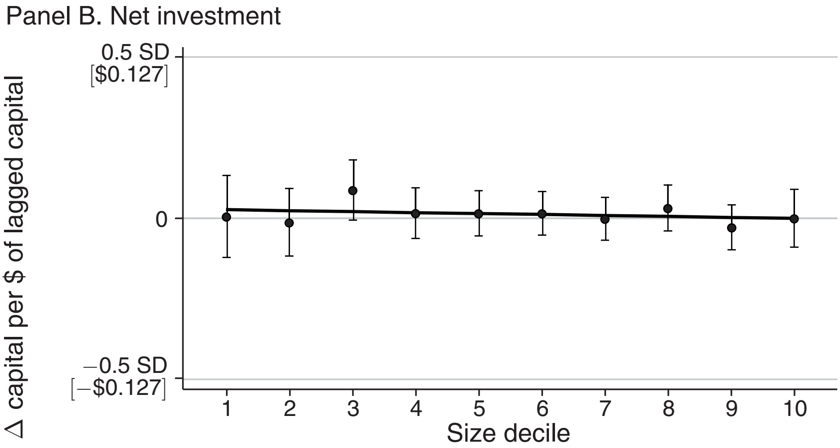


FIGURE 2. EFFECTS OF THE 2003 DIVIDEND TAX CUT

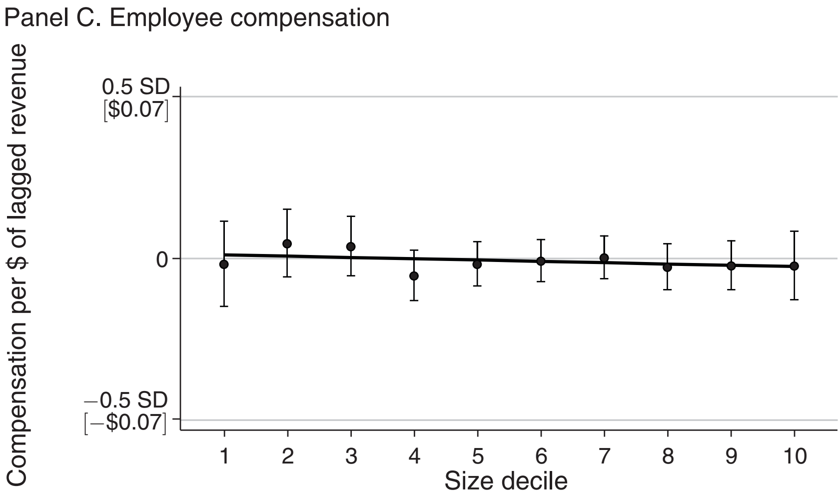
Investment effects by size decile



Net Investment effects by size decile



Employee compensation effects by size decile



Regressions

TABLE 2—EFFECT OF THE 2003 DIVIDEND TAX CUT ON INVESTMENT, NET INVESTMENT, AND EMPLOYEE COMPENSATION

Dependent variable:	Investment					
Dep. var. winsorized at:	95th percentile			99th percentile		
Panel:	Unbalanced		Balanced	Unbalanced		Balanced
	($ per lagged capital)		($ per 96–97 cap.)	($ per lagged capital)		($ per 96–97 cap.)
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A. Investment						
C-Corp × Post-2003	0.0008	−0.0002	−0.0063	−0.0104	−0.0118	−0.1884
	(0.0044)	(0.0042)	(0.0226)	(0.0068)	(0.0066)	(0.1483)
Lagged controls		X			X	
Firm FE's			X			X
Observations (firm-years)	333,029	333,029	85,624	333,029	333,029	85,624
Clusters (firms)	73,188	73,188	7,784	73,188	73,188	7,784
R^2	0.01	0.07	0.53	0.01	0.05	0.55
Pre-2003 C-corp mean	0.2428	0.2428	0.2939	0.2828	0.2828	0.3682
Pre-2003 C-corp SD	0.2514	0.2514	0.3070	0.4181	0.4181	0.6478
Implied ε wrt $(1-\tau_{div})$	0.01	0.00	−0.05	−0.09	−0.10	−1.18
	[−0.08, 0.09]	[−0.08, 0.08]	[−0.4, 0.3]	[−0.19, 0.02]	[−0.2, 0.01]	[−3.01, 0.64]

Regressions

Dependent variable:	Net investment			Employee compensation		
Dep. var. winsorized at:	95th percentile					
Panel:	Unbalanced		Balanced	Unbalanced		Balanced
	($ per lagged capital)		($ per 96–97 cap.)	($ per lagged revenue)		($ per 96–97 rev.)
	(7)	(8)	(9)	(10)	(11)	(12)
B. Net investment and employee compensation						
C-Corp $\times$ Post-2003	0.0048	0.0042	−0.0110	−0.0013	−0.0013	0.0083
	(0.0041)	(0.0039)	(0.0116)	(0.0025)	(0.0020)	(0.0062)
Lagged controls		X			X	
Firm FE's			X			X
Observations (firm-years)	333,029	333,029	85,624	333,029	333,029	85,624
Clusters (firms)	73,188	73,188	7,784	73,188	73,188	7,784
R^2	0.01	0.04	0.20	0.00	0.37	0.87
Pre-2003 C-corp mean	0.0421	0.0421	0.0885	0.1647	0.1647	0.1727
Pre-2003 C-corp SD	0.2541	0.2541	0.2732	0.1415	0.1415	0.1450
Implied ε wrt $(1-\tau_{div})$	0.26	0.23	−0.29	−0.02	−0.02	0.11
	[−0.18, 0.71]	[−0.19, 0.66]	[−0.88, 0.3]	[−0.09, 0.05]	[−0.07, 0.04]	[−0.05, 0.27]

Confirmation of Salience and Relevance

Table 4—Effect of the 2003 Dividend Tax Cut on Total Payouts to Shareholders (*Percent*)

Panel:	Unbalanced		Balanced	Unbalanced		Balanced
	(1)	(2)	(3)	(4)	(5)	(6)
C-Corp × Post-2003	23.4	27.6	78.1	39.4	45.5	53.6
	(3.6)	(3.3)	(8.0)	(7.3)	(6.5)	(15.1)
C-Corp × Year-2003	18.1	21.4	58.5	26.2	30.5	45.1
	(4.3)	(4.1)	(8.8)	(4.8)	(4.6)	(11.3)
C-Corp × Year-2004	32.1	35.6	66.6	43.3	48.3	48.8
	(5.2)	(5.0)	(11.4)	(6.5)	(6.2)	(10.4)
C-Corp × Year-2005	26.8	29.8	81.4	41.2	46.0	59.1
	(5.8)	(5.5)	(12.4)	(8.2)	(7.5)	(16.6)
Lagged controls		X			X	
Firm FE's			X			X
Pre-trend controls				X	X	X
Observations (firm-years)	333,029	333,029	85,624	333,029	333,029	85,624
Clusters (firms)	73,188	73,188	7,784	73,188	73,188	7,784
Pre-2003 C-corp mean ($ per lagged revenue)	0.0031	0.0031	0.0061	0.0031	0.0031	0.0061

Fuest et al. (2018)

Abstract. This paper estimates the incidence of corporate taxes on wages using a 20-year panel of German municipalities exploiting 6,800 tax changes for identification. Using event study designs and difference-in-differences models, we find that workers bear about one-half of the total tax burden. Administrative linked employer-employee data allow us to estimate heterogeneous firm and worker effects. Our findings highlight the importance of labor market institutions and profit-shifting opportunities for the incidence of corporate taxes on wages. Moreover, we show that low-skilled, young, and female employees bear a larger share of the tax burden. This has important distributive implications.

Fuest et al. (2018)

Panel A. Local tax rates in 2003

Panel B. Scaling factor changes per municipality, 1993–2012

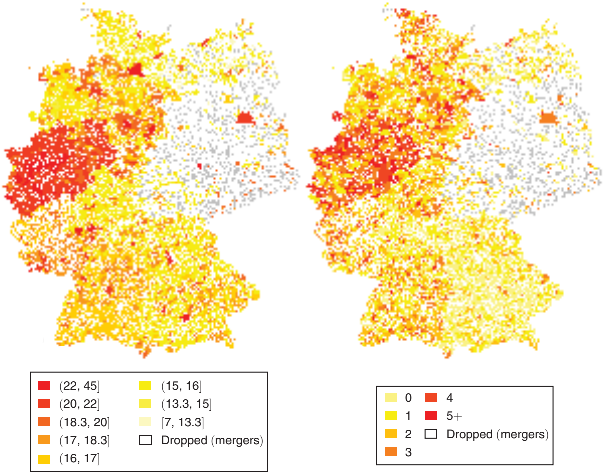
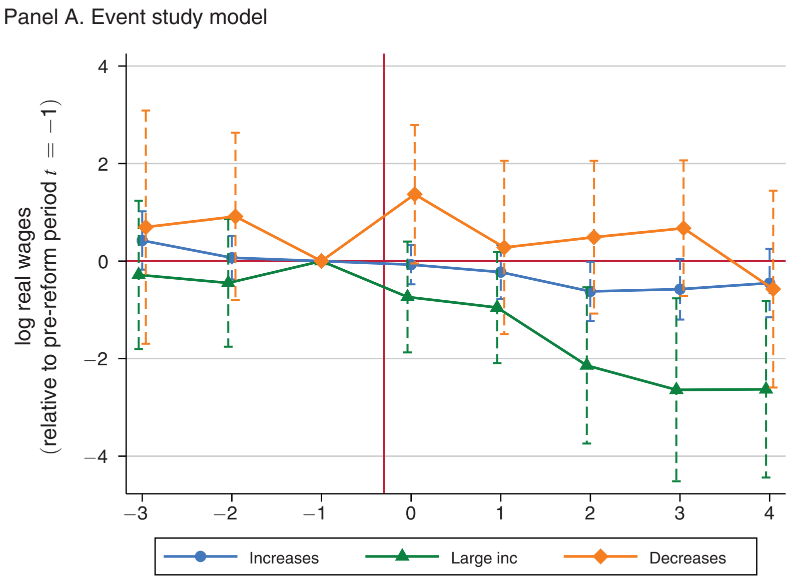


FIGURE 1. CROSS-SECTIONAL AND TIME VARIATION IN LOCAL TAX RATES

Fuest et al. (2018)



Fuest et al. (2018)

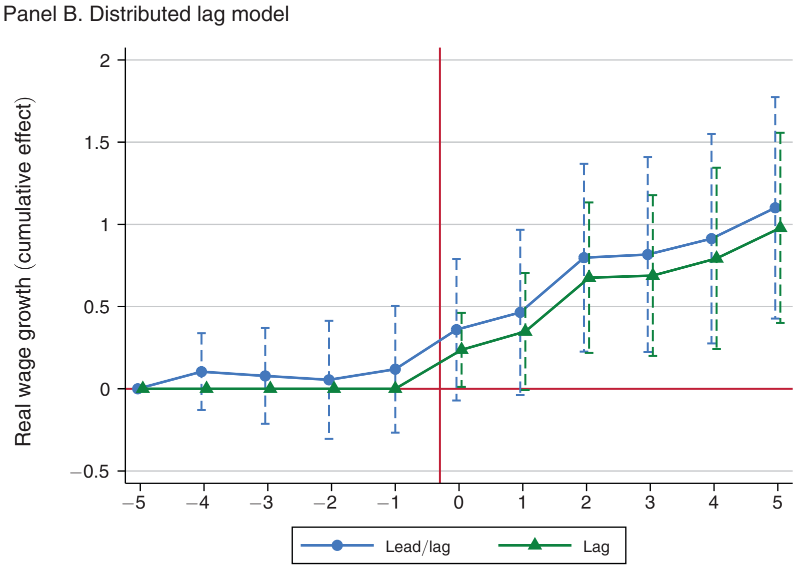
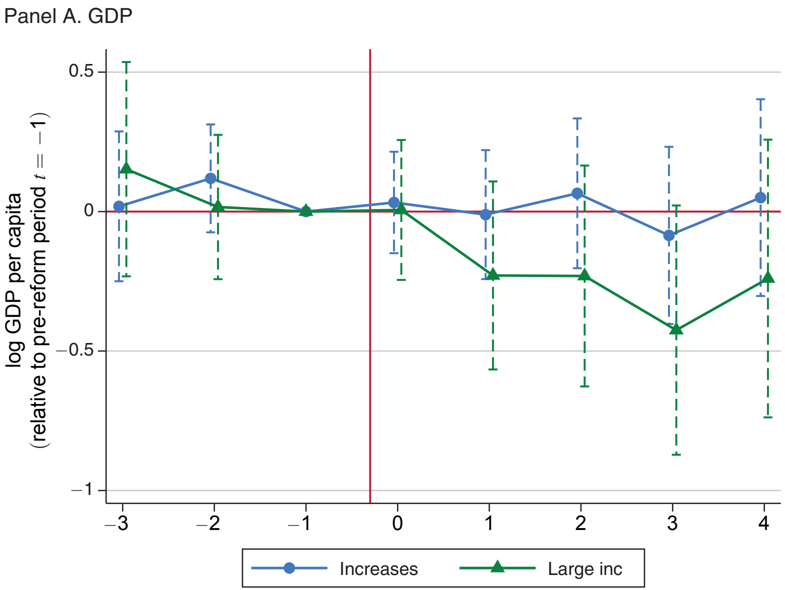
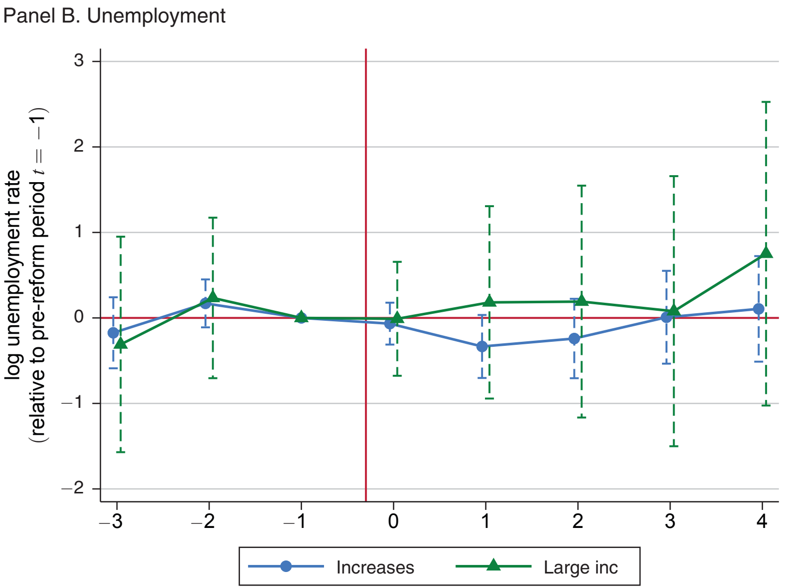


FIGURE 3. BASELINE WAGE EFFECTS

Fuest et al. (2018)



Fuest et al. (2018)



Tentative conclusion

- We need more empirical work.
- Unitary elasticity (Cobb–Douglas) is probably not the answer. Most microeconomic studies suggest a rather low elasticity. Impact for macroeconomic models?
- The last tax reform in the US may provide a case in point. Many other tax reforms can be used.

Bibliography I

Acemoglu, Daron, *Introduction to Modern Economic Growth*, Princeton University Press, January 2009. Google-Books-ID: jOj4P3NMreMC.

Caballero, Ricardo J., "Chapter 12 Aggregate investment," in "Handbook of Macroeconomics," Vol. 1, Elsevier, January 1999, pp. 813–862.

Chaney, Thomas, David Sraer, and David Thesmar, "The Collateral Channel: How Real Estate Shocks Affect Corporate Investment," *American Economic Review*, May 2012, *102* (6), 2381–2409.

Chirinko, Robert S., "Business Fixed Investment Spending: Modeling Strategies, Empirical Results, and Policy Implications," *Journal of Economic Literature*, 1993, *31* (4), 1875–1911.

Clark, J. Maurice, "Business Acceleration and the Law of Demand: A Technical Factor in Economic Cycles," *Journal of Political Economy*, 1917, *25* (3), 217–235.

Cobb, Charles W. and Paul H. Douglas, "A Theory of Production," *The American Economic Review*, 1928, *18* (1), 139–165.

Cummins, Jason G., Kevin A. Hassett, R. Glenn Hubbard, Robert E. Hall, and Ricardo J. Caballero, "A Reconsideration of Investment Behavior Using Tax Reforms as Natural Experiments," *Brookings Papers on Economic Activity*, 1994, *1994* (2), 1–74.

Bibliography II

Fazzari, Steven M., R. Glenn Hubbard, Bruce C. Petersen, Alan S. Blinder, and James M. Poterba, "Financing Constraints and Corporate Investment," *Brookings Papers on Economic Activity*, 1988, *1988* (1), 141–206.

Fuest, Clemens, Andreas Peichl, and Sebastian Siegloch, "Do Higher Corporate Taxes Reduce Wages? Micro Evidence from Germany," *American Economic Review*, February 2018, *108* (2), 393–418.

Hall, Robert E. and Dale W. Jorgenson, "Tax Policy and Investment Behavior," *The American Economic Review*, 1967, *57* (3), 391–414.

Hassett, Kevin A. and R. Glenn Hubbard, "Tax Policy and Investment," Working Paper 5683, National Bureau of Economic Research July 1996.

Jorgenson, Dale W., "Capital Theory and Investment Behavior," *The American Economic Review*, 1963, *53* (2), 247–259.

Mian, Atif and Amir Sufi, "What Explains the 2007–2009 Drop in Employment?," *Econometrica*, November 2014, *82* (6), 2197–2223.

__ **, Kamalesh Rao, and Amir Sufi**, "Household Balance Sheets, Consumption, and the Economic Slump," *The Quarterly Journal of Economics*, November 2013, *128* (4), 1687–1726.

Bibliography III

Piketty, Thomas and Gabriel Zucman, "Capital is Back: Wealth-Income Ratios in Rich Countries 1700–2010," *The Quarterly Journal of Economics*, August 2014, *129* (3), 1255–1310.

Shapiro, Matthew D., Olivier J. Blanchard, and Michael C. Lovell, "Investment, Output, and the Cost of Capital," *Brookings Papers on Economic Activity*, 1986, *1986* (1), 111–164.

Summers, Lawrence H., Barry P. Bosworth, James Tobin, and Philip M. White, "Taxation and Corporate Investment: A q-Theory Approach," *Brookings Papers on Economic Activity*, 1981, *1981* (1), 67–140.

Yagan, Danny, "Capital Tax Reform and the Real Economy: The Effects of the 2003 Dividend Tax Cut," *American Economic Review*, December 2015, *105* (12), 3531–3563.