Macroeconomic Effects of the U.S. Product Market Deregulation

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Abstract

In the early 1980s the U.S. economy experienced a significant and persistent rise in the rate of investment-specific technical change (ISTC) that has boosted economic growth in recent decades. The macroeconomic consequences of faster ISTC are well understood. However, little is known about its origins. In this paper, we argue that the deregulation of U.S. product markets, as initiated by the Ford/Carter Administrations in the late 1970s, contributed to the acceleration of ISTC. We document that this acceleration is especially pronounced for deregulated industries which also show faster labor productivity growth. We develop a multi-sector general equilibrium model of endogenous ISTC that features imperfect competition and a technology choice by firms. The framework is used (a) to study the industry and macroeconomic effects of competition policy, and (b) to quantitatively assess to what extent the Ford/Carter regulatory reforms can account for the observed acceleration of ISTC and the subsequent divergence of labor productivity across U.S. industries. The quantitative experiment generates more than two thirds of the acceleration in ISTC for the deregulated industries and about a quarter of the divergence of labor productivities across industries.

JEL classification: D43, E02, L16, O33
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1 Introduction

In the early 1980s the U.S. economy experienced a substantial and persistent rise in the rate of investment-specific technical change (ISTC). Evidence provided by Cummins and Violante (2002); Krusell, Ohanian, Ríos-Rull, and Violante (2000); Pakko (2002b,c); and others suggests that until the 1970s investment-specific technical change was fairly stable between 3% and 4% but it started to accelerate in the early 1980s leading to annual rates of more than 6% in the subsequent decades.[1] This acceleration in ISTC was the main driver of the U.S. growth resurgence in the 1990s.[2] However, little is known about its origins.

At about the same time, labor productivity across U.S. industries started to diverge: industries of the communications, energy, finance, and transportation sectors experienced a considerable hike in productivity growth. On average, their growth rate rose by more than 3% percentage points in the 1980s and 1990s while other private industries continued to grow at an annual rate of 1%. Consequently, those industries contributed substantially to the U.S. growth resurgence. Remarkably, communications, energy, finance, and transportation were prime target of the regulatory reforms of the Ford and Carter Administrations.

This observation suggests the question whether a change in competition policy is able to explain a such rise in productivity growth. To this end, we propose a general equilibrium multi-sector model of endogenous investment-specific technical change and study industry and macroeconomic effects of competition policy. We use a version of the model economy calibrated to U.S. data to assess quantitatively to which extent the Ford/Carter regulatory reforms can account for the observed acceleration of ISTC and the subsequent divergence of labor productivity in the U.S.

The present study contributes in three respects: first, we empirically document that those industries that were deregulated in the late 1970s performed fundamentally differently in the subsequent decades than those not directly affected by the Ford/Carter reforms. In particular, deregulated industries experienced faster investment-specific technical change and substantially higher labor productivity growth than the rest of the U.S. economy. One reason is that they reduced their technological backwardness by replacing old capital with state-of-the-art equipment.

Second, we provide a general equilibrium multi-sector model framework to investigate industry and macroeconomic effects of competition policy. In the model, deregulation

[1]Structural-break tests by Pakko (2005) provide overwhelming evidence for a breakpoint in 1983.

[2]E.g., Cummins and Violante (2002); Martínez, Rodríguez, and Torres (2010); Pakko (2002c, 2005).

of entry restrictions encourages new competitors to enter the products market. Intensified competition leads to lower prices and expanding production. Firms install additional capital which fosters R&D activities to improve investment goods. Investment-specific technical change accelerates and, hence, labor productivity grows at a higher rate.

Third, our quantitative experiment finds that about 70% of the observed acceleration in ISTC for the deregulated industries and almost a fifth of the overall acceleration for the U.S. economy can be explained by the Ford/Carter reforms. Furthermore, deregulation leads to a divergence of labor productivities across industries, as in the data.

In a seminal paper, Greenwood, Hercowitz, and Krusell (1997) find that the introduction of new, more efficient capital goods is the major source of U.S. post-war growth. Besides, the observed acceleration in ISTC called forth vivid interest. A large literature discusses its consequences for various macroeconomic outcomes. Among the more recent contributions are Krusell, Ohanian, Ríos-Rull, and Violante (2000) studying the rise in the skill premium; Hornstein, Krusell, and Violante (2007) focusing on policy outcomes; Duernecker (2013) studying the divergence of unemployment rates; and Marimon and Zilibotti (1999) addressing the rise in labor market frictions. This paper proposes a cause.[3]

In addition, the current study contributes to the literature investigating the macroeconomic effects of deregulation such as Blanchard and Giavazzi (2003) examining the interaction of product market and labor market regulations, Bertinelli, Cardi, and Sen (2013); Ebell and Haefke (2009); Fang and Rogerson (2011) studying effects of deregulation on labor market outcomes, and Alesina, Ardagna, Nicoletti, and Schiantarelli (2005); Barone and Cingano (2011); Dawson and Seater (2013); Nicoletti and Scarpetta (2003) estimating growth effects. One of the main differences is that our paper considers a multi-industry framework similar to Ngai and Samaniego (2009) which allows us to model industry-specific deregulation and investigate inter-industry input-output linkages.

It is also related to the large literature on the relationship between competition and innovation (e.g. Klette and Griliches (2000); Vives (2008) in partial equilibrium, and Aghion, Bloom, Blundell, Griffith, and Howitt (2005); Aghion, Harris, Howitt, and Vickers (2001) in general equilibrium). However, these papers focus on in-house R&D and process innovation by product market firms while this paper considers R&D activities that are outsourced and lead to investment-specific technical change.

[3] So far, little is known about the origins of this acceleration in ISTC. Boucekkine, del Río, and Licandro (2003), who a study two-sector learning-by-doing model, find that an exogenous change in learning efficiency favoring investment goods over consumption goods could explain faster ISTC. However, they do not provide an explanation for such an "technological reassignment" in the late 1970s.

The rest of this paper is organized as follows: Section 2 gives a summary of the regulatory reforms under presidents Ford and Carter. Section 3 presents a set of macroeconomic developments of the U.S. economy during the 1980s and 1990s. Section 4 sets up the model. Section 5 calibrates the model, describes our policy experiment, and reports the findings. Section 6 summarizes the paper and offers some concluding comments.

2 U.S. Product Market Deregulation

In the late 1970s and early 1980s a wave of regulatory reforms affected the U.S. economy. Within less than a decade presidents Ford, Carter, and – to a lesser extent – Reagan liberalized virtually every previously regulated sector of the American economy. Originating from a novel attitude towards economic regulation, this regulatory reform movement marked an extraordinary turning point in U.S. economic policy.[4]

The reforms addressed both the nature and extent of regulation. Output restrictions were given up, rate-of-return regulation came to an end, price controls were abolished, licensing was replaced by free entry, and regulatory agencies like the Civil Aeronautics Board or the Federal Power Commission were closed down (Joskow and Noll, 1994; Weiss and Klass, 1986). Most affected by this liberalization of regulatory restrictions are the following industries: communications, energy, finance, and transportation. Table 1 provides an overview of those regulatory reforms by industry. Joskow and Noll (1994); Weiss and Klass (1986); Winston (1993, 1998) portray the regulatory changes in detail. Distilling their accounts of deregulation, we conclude that in the 1970s entry restrictions were an omnipresent measure of regulation. Subsequently, groundbreaking regulatory changes have altered industry structures, operation practices, and pricing conditions.

Basically, the market conditions under which about one sixth of U.S. GDP were produced changed completely. But these industries did not only produce 16% of GDP and employ 12% of the labor force before the reforms took place. Rather, about 55% of their output was input to other U.S. industries, making up 22% of total intermediate inputs. This suggests that deregulated industries were well connected to the whole U.S. economy. Hence, input-output relationships might be an important channel for spillover effects.

[4]Winston (1993, p. 1263) assesses the economic deregulation of American industry as "one of the most important experiments in economic policy of our time".

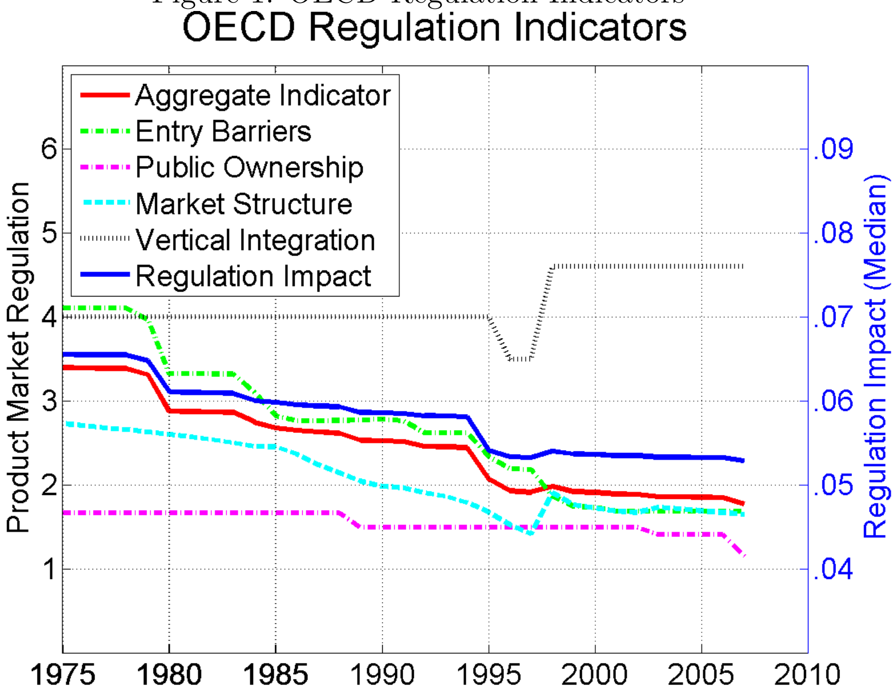
Table 1: Regulatory reform

Industry	Regulatory Agencies[a]	Regulatory Changes	Major Initiatives
Airlines	Civil Aeronautics Board (1985)	phased out route regulation, eliminated regulations on fares	CAB initiatives (mid 1970s), Airline Deregulation Act (1978)
Passenger Transit	Interstate Commerce Commission (1996)	relaxed entry controls, freed up rates, abolished some types of collective rate making	Federal Bus Regulatory Reform Act (1982)
Shipping	Federal Maritime Commission	permitted independent rate making	Ocean Shipping Act (1984)
Road transport	Interstate Commerce Commission (1996), state agencies	rates could be set independently but had to be filed, entry restrictions were eliminated	ICC initiatives (late 1970s), Motor Carrier Reform Act (1980)
Railroads	Interstate Commerce Commission (1996)	liberalization of rates and contracting, permission to abandon routes and of mergers	ICC initiatives (late 1970s), Railroad Revitalization and Regulatory Reform Act (1976), Staggers Rail Act (1980)
Telecommunications	Federal Communications Commission, state agencies	industry restructuring, deregulation of equipment prices and long distance rates, open entry	Agency initiatives, Court Decisions (by mid 1970s), Execunet Decision (1977), AT&T Settlement (1982)
Cable Television	Federal Communications Commission, municipalities	price deregulation	FCC initiatives (late 1970s), Cable Television Deregulation Act (1984)
Brokerage	Securities and Exchange Commission	outlawed fixed brokerage rates	Securities Acts Amendments (1975)
Banking	Federal Savings and Loan Insurance Corporation (1989), Federal Deposit Insurance Corporation, Federal Reserve Board, Comptroller of the Currency	eliminated interest rate ceilings, deregulated deposit services, liberalized investment portfolios, permitted interstate bank branching and commercial bank ownership of subsidiaries in investment banking	Depository Institutions Deregulation and Monetary Control Act (1980), Garn-St. Germain Act (1982), Financial Institutions Reform, Recovery, and Enforcement Act (1989)
Petroleum	Federal Energy Administration	phased out controls on domestic crude oil prices	executive orders (beginning in 1979)
Natural Gas	Federal Power Commission (1977), Federal Energy Regulatory Commission, state agencies	deregulation of field prices, created open access to interconnected grid, unbundling of gas supplies, contractual revisions	Agency initiatives, Natural Gas Policy Act (1978), Fuel Use Act (1978)
Electric power	Federal Energy Regulatory Commission, state agencies	deregulation of field prices, created open access to interconnected grid, unbundling of gas supplies, contractual revisions	Public Utility Regulatory Act (1982)

[a] Year of dissolution in parentheses.

Sources: Joskow and Noll (1994); OECD (1999); Weiss and Klass (1986); Winston (1993, 1998)

Figure 1: OECD Regulation Indicators



NOTES: The Regulation Impact Indicator is computed at the industry level. We illustrate the median value of the Regulation Impact Indicator for every year.
DATA SOURCE: Organisation for Economic Co-operation and Development, Product Market Regulation Database.

The fact that liberalizing operations, pricing, entry and exit has permeated broad fields of the American economy is also reflected in the OECD regulatory indicators. Consisting of five sub-indicators (entry barriers, public ownership, market structure, vertical integration, and price controls), the OECD constructs a measure for the intensity of product market regulation in the energy, communications, and transportation sector (Conway and Nicoletti, 2006).[5] Furthermore, the OECD provides a Regulation Impact Indicator measuring how other industries are affected by regulation in the energy, communications, and transportation sector through input-output relations.

Figure 1 illustrates these indicators. Both the aggregate Product Market Regulation Indicator and the Regulation Impact Indicator show a declining trend with two pronounced drops: the Ford/Carter/Reagan and the Clinton deregulation. The three sub-indicators

[5]The scale from 0 to 6 reflects increasing restrictiveness of regulatory provisions.

for public ownership, market structure, and entry barriers show a similar evolution. In particular, entry barriers were substantially reduced, most notably around 1979 and 1984.

Ebell and Haefke (2009), for example, estimate hat entry costs in the late 1970s were about the ninefold of their late-1990s level.[6] Finally, an international comparison of the OECD indicators reveals that the U.S. were in the vanguard of the deregulation movement.

3 Macroeconomic Developments

This section documents the long-run development of several macroeconomic outcomes in the U.S. The main message is that those industries that were deregulated in the late 1970s experienced a fundamentally different evolution subsequently than those not directly affected by the Ford/Carter reforms.

One development which has attracted a lot of attention in the literature is the acceleration of investment-specific technical change in the U.S.[7] It is a well-documented fact that there was a substantial and persistent rise in the rate of ISTC by about 2.5 percentage points in the early 1980s (Cummins and Violante, 2002; Pakko, 2002c, 2005).[8] Reporting the Cummins and Violante (2002) data, the first row of Table 2.A illustrates this acceleration.

In addition, we establish that the acceleration of ISTC was more powerful in deregulated industries than in the rest of the U.S. economy. To this end, we construct measures of ISTC at the industry level which aggregate asset-specific ISTC rates into industry-level rates (Table 2).[9] Between 1960 and 1975 the ISTC rate for deregulated industries (3.8% p.a.) was lower than for all other private industries (4.4% p.a.). However, during the 1980s and 1990s deregulated industries experienced an acceleration by 3.5 percentage points to 7.3% per year, while all other industries increased their ISTC rate by 2.1 percentage points.[10]

[6]Following a similar approach, Bertinelli, Cardi, and Sen (2013) estimate a relationship between the aggregate PMR indicator and price-cost margins. Their results suggest that the average price-cost margin in U.S. declined by 5.3 percentage points since the late 1970s to about 1.5.

[7]Cummins and Violante (2002); Greenwood, Hercowitz, and Krusell (1997), for example, find that investment-specific technical change is one of the major determinants of U.S. productivity growth. They quantify the contribution of ISTC to post-war growth to approximately 60%.

[8]Table 9 in the Appendix gives a broad overview of the literature documenting this rise in ISTC.

[9]The aggregation method, a Tornqvist procedure, is described in Appendix C.1.1.

[10]We run panel-data regressions to estimate the causal effect of the Ford/Carter deregulation on the industry rate of ISTC (see Appendix A). The difference-in-difference estimate attributes an acceleration of 1.3 percentage points to the regulatory reforms. However, we regard this estimate to be a lower bound since the regression analysis does not allow for spillover effects. Nevertheless, the regression analysis confirms

Table 2: Average annual rate of ISTC

	A: current investment shares[a]				B: 1975 investment shares[b]		
	1960-75	1980-89	1990-2000	Δ	1980-89	1990-2000	Δ
aggregate	4.1	5.0	6.9	+2.8	3.7	4.9	+0.8
de/regulated	3.8	5.2	7.3	+3.5	4.9	6.8	+3.0
others	4.4	4.7	6.5	+2.1	3.1	4.0	-0.4

Aggregate refers to Private industries; de/regulated does not only include de/regulated industries (Energy and utilities, Communications, Transportation, and Brokers) but also industries "severely affected by deregulative reform" according to the OECD Regulatory Impact indicator; other industries are all remaining private industries.

[a] We follow the Tornqvist procedure employed by Cummins and Violante (2002) to aggregate asset-level ISTC rates into industry-level ISTC rates. To compute the asset's share in industry investment we use the detailed estimates from BEA's Fixed Asset Accounts.

[b] Panel B is computed using a Tornqvist procedure but holding the investment composition fixed at its 1975 shares. That way, we decompose the acceleration of ISTC into two origins: first, an acceleration due to a shift in investment from low-ISTC to high-ISTC assets. Second, an acceleration purely due to an acceleration of ISTC in underlying assets. The latter is reported here.

Sources: Cummins and Violante (2002); Bureau of Economic Analysis, Fixed Asset Accounts.

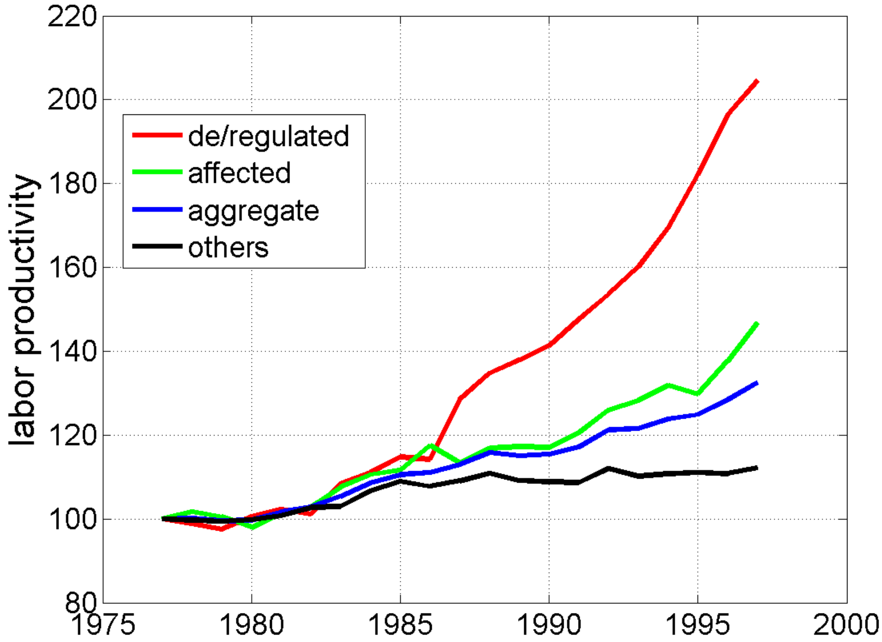
Interestingly, the sources of this acceleration differ as well, as the decomposition in Table 2.B reveals. Deregulated industries attained high rates of ISTC mainly by replacing their old equipment capital with state-of-the-art vintages while keeping their composition of investment stable.[11] This way, deregulated industries took advantage of the acceleration in ISTC of capital assets they use intensively, especially new information and communication technologies. In contrast, the remaining industries shifted their investment to high-ISTC assets. This composition effect contributes about 2 percentage points to their ISTC rate (Table 2).

At the same time, labor productivity across U.S. industries started to diverge as Figure 2 shows. Average U.S. labor productivity growth was about 1% per year during the period 1965-1980 and increased to 1.4% p.a. in 1980-1995. This increase was mainly driven by deregulated industries: their labor productivity growth amounted to 4% p.a. during the post-deregulation period while other private industries continued to grow at an annual rate

that deregulated industries experienced a faster acceleration of ISTC than the rest of the U.S. economy.

[11] Documenting a reduction their technological gap, Figure 3 supports this view.

Figure 2: Labor productivity diverges



NOTES: Labor productivity is computed as real value-added per full-time equivalent employee. Aggregate refers to Private industries; de/regulated industries are Energy and utilities, Communications, Transportation, and Brokers; affected industries are those private industries that obtained more than 20 % of their intermediate inputs from de/regulated industries; other industries are all remaining Private industries.
DATA SOURCE: Bureau of Economic Analysis, NIPA.

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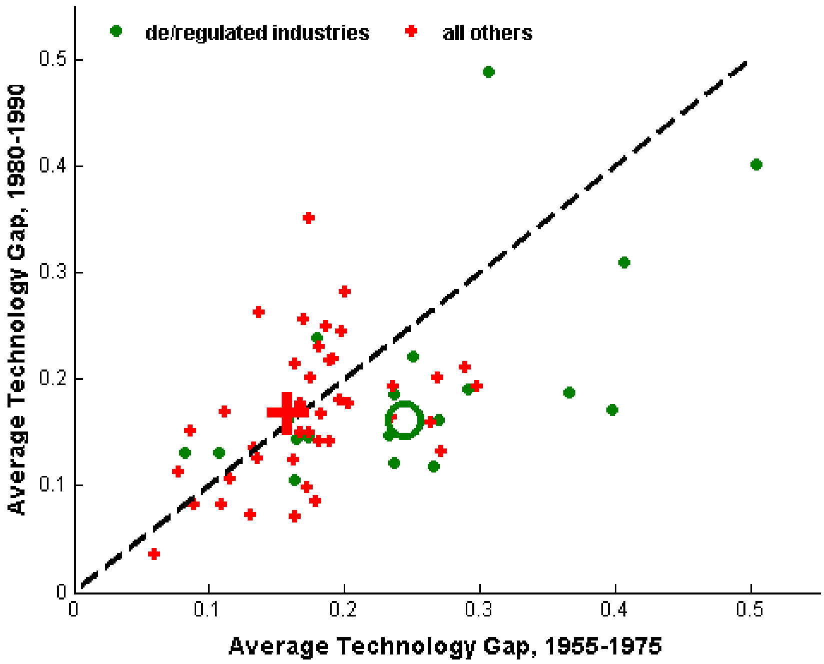
of 1%. Those private industries that obtained more than 20% of their intermediate inputs from de/regulated industries, in contrast, have grown faster. This finding suggests that these industries may have benefited from the faster productivity growth of deregulated industries through input-output linkages.

The simultaneity of this growth acceleration and the Ford/Carter reforms might point to a causal link such as competitive pressures inducing a battle for technological leadership. The following pieces of evidence tend to be in line with such a view.

Figure 3 compares the technological gaps of U.S. industries for two periods. The technological gap measures how much more productive new capital goods are compared to the average vintage.[12] The figure reveals that during the pre-deregulation period the techno-

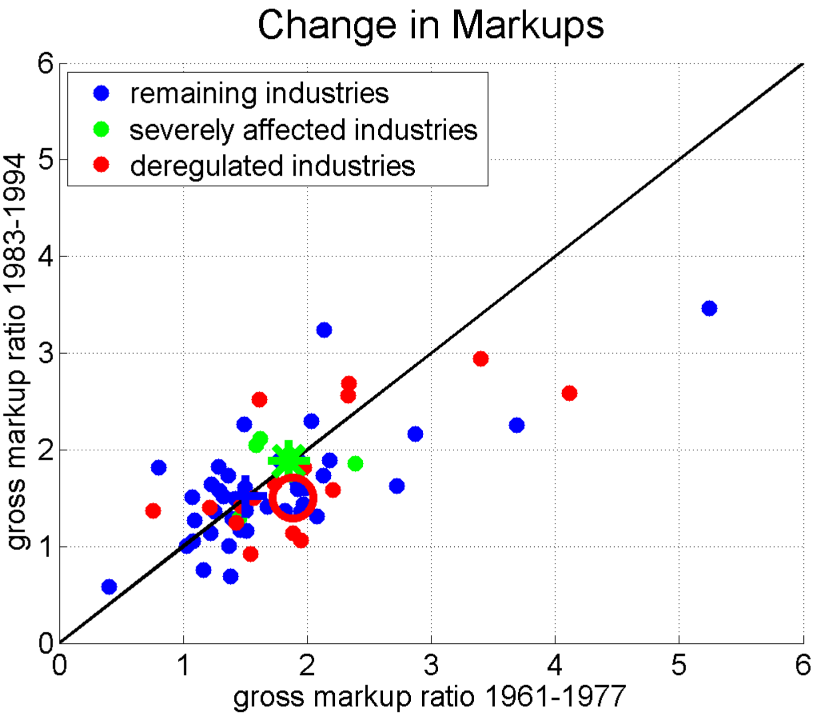
[12]Cummins and Violante (2002) define the technology gap Γ between a new machine and the average

Figure 3: Technology gap closes



Notes: Following Cummins and Violante (2002) the technology gap for an industry Γ is computed as the efficiency gap between the leading-edge technology q and average practice Q relative to the average efficiency level of the industry's capital stock: $\Gamma = (q - Q)/Q$.
Data Source: Cummins and Violante (2002).

Figure 4: Markups



NOTES: The figure displays estimates of industry gross markups for two periods: 1961-77 and 1983-1994 (for details see Appendix B). Bullets below the 45°-line indicate industries that experienced a decline in markup, while bullets above suggest an increase in markups.
DATA SOURCE: Bureau of Economic Analysis, GDP-by-Industry Accounts & Fixed Asset Accounts.

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logical gap of deregulated industries was higher than for other industries. This means, deregulated industries initially operated with technologies more distant from the technology frontier, leaving scope for technological catch-up. While for all other industries the technological gap remained stable, the gap closed for deregulated industries subsequent deregulation, matching the rest of the U.S. economy.

Figure 4 suggests that competitive pressures have increased in the U.S. ensuing the Ford/Carter deregulation. The figure displays estimates of the gross markup for two periods: 1961-77 and 1983-1994 (see Appendix B). Each bullet depicts a single industry. Most bullets are below the 45°-line which means that these industries experienced a decline in the markup after the regulatory reforms. This is particularly true for the majority of dereg-

machine as the efficiency gap between the leading-edge technology q and average practice Q relative to the average efficiency level of the corresponding capital stock: $\Gamma = (q - Q)/Q$.

ulated industries. For them, the gross markup decreased, on average, by 22 percentage points from 1.92 to 1.71 (Table 7 in the Appendix). Similarly, markups in severely affected industries decline on average by 35 percentage points, while for the remaining private industries there is essentially no change. However, these estimates should be treated with caution as the number of observations is small and standard errors are high.

4 The Model

This section develops a multi-sector general equilibrium model of endogenous technical change. The economy is populated by an infinitely-lived representative household. The production side of the economy consists of a final good sector, a products sector, and a R&D sector. The final goods sector competitively assembles an all-purpose numeraire good from intermediate products.

The products sector consists of a large number of industries. Each industry produces its own output good using capital, labor, and intermediate inputs. In the model, governmental regulation raises barriers to entry and leads to imperfect competition in product markets. We focus on legal and administrative restrictions to entry. The reason is that only those deregulative measures that decrease the rents required to enter and stay in the market will permanently be effective in spurring competition, as Blanchard and Giavazzi (2003) find.

R&D activities improve the quality of capital goods in the spirit of Aghion and Howitt (1992); Grossman and Helpman (1991). However, the precise formulation of the R&D sector is close to Krusell (1998)'s model of endogenous ISTC in which innovations are embodied in investment goods. This is a simple way to model productivity growth which is driven by the ongoing development of better equipment.

4.1 Economic Environment

Final good composite. In the economy there is a final good Y which can be used for consumption purposes C, investment X as well as R&D activities S. Furthermore, entry costs that might be paid arise in terms of the final good. This final good is a composite of products which are assembled under perfect competition according to a Cobb-Douglas aggregator

$$(1) \qquad Y = \prod_{i=1}^{I} \left(y_i^f\right)^{\theta_i^Y}, \quad \theta_i^Y \geq 0 \; \forall i, \quad \sum_{i=1}^{I} \theta_i^Y = 1$$

where y_i^f is final demand of the product produced by industry i. The price index corresponding to the final good is $P^Y = \prod_{i=1}^{I} \left(p_i/\theta_i^Y\right)^{\theta_i^Y}$ where p_i is the price of industry i's output. We choose the final good as the numeraire and normalize $P^Y = 1$. Hence, the aggregate resource constraint reads as $Y = C + X + S + E$ where E denotes aggregate entry costs paid.

Products. The economy consists of a large but finite number of industries I. Each industry i is populated by a finite number of product market firms N_i which produce a perishable differentiated product $\mathbf{y}_i$. This product can be used for final demand y_i^f or as intermediate input y_i^z by other industries: $\mathbf{y}_i = y_i^f + y_i^z$.

It is produced from capital $\mathbf{k}$, labor h, and intermediate inputs $\mathbf{z}$. The main difference between intermediate inputs and capital is that the latter is accumulable and can be used for production for more than one period, whereas the former is non-storable and gets used up in production. All incumbent firms of an industry operate according to the same Cobb-Douglas technology

$$(2) \qquad y_{ij} = A_i \mathbf{k}_{ij}^{\alpha_i^k} \mathbf{z}_{ij}^{\alpha_i^z} h_{ij}^{1-\alpha_i^k-\alpha_i^z} \qquad 0 < \alpha_i^k, \alpha_i^z, \quad \alpha_i^k + \alpha_i^z \leq 1, \; \forall i$$

where the subscript ij denotes firm j in industry i. $A_i > 0$ is an industry-specific productivity parameter. The firm uses intermediate inputs from other industries, each representing a different input variety. The firm's total input of intermediate goods is denoted by $\mathbf{z}_{ij}$. It is given by a Cobb-Douglas aggregator of the different input varieties:

$$(3) \qquad \mathbf{z}_{ij} = \prod_{l \neq i}^{I} \left(z_{l,ij}\right)^{\theta_{l,i}^{\mathbf{z}}}, \quad \theta_{l,i}^{\mathbf{z}} \geq 0 \; \forall l \neq i, \quad \sum_{l \neq i}^{I} \theta_{l,i}^{\mathbf{z}} = 1$$

where z_l is the quantity of the intermediate input obtained from sector l.

The firm's capital stock is not homogeneous but it consists of different varieties of capital goods such as computers, machines, structures, etc. A particular variety is denoted by $\nu \in \{1, ..., \bar{\nu}\}$ where $\bar{\nu}$ denotes the total number of varieties available. Total capital input **k** is a Cobb-Douglas aggregator of the different varieties employed by the firm:

$$\mathbf{k}_{ij} = \prod_{\nu=1}^{\bar{\nu}} (k_{\nu,ij})^{\theta^k_{\nu,i}} \quad \theta^k_{\nu,i} \geq 0 \; \forall \nu, \quad \sum_{\nu=1}^{\bar{\nu}} \theta^k_{\nu,i} = 1 \tag{4}$$

where k_ν is the quantity of variety ν and $\theta^k_{\nu,i}$ is the associated weight. As there is investment-specific technical change, capital stocks are measured in efficiency units. This means, that $x_{\nu,t}$ units of investment contribute $\phi_{\nu,t} \cdot x_{\nu,t}$ effective units to the capital stock, where $\phi_{\nu,t}$ is the quality of period t investment goods. The capital stock depreciates at rate δ_ν. Hence, the law of motion of the firm's capital stock of variety ν reads:

$$k_{\nu,ij,t+1} = (1-\delta_\nu) k_{\nu,ij,t} + \phi_{\nu,ij,t} \cdot x_{\nu,ij,t} \quad \forall \nu \tag{5}$$

Product market incumbents. Consider any product market incumbent in an industry. The incumbent's state consists of the capital stocks he owns: $\{k_{\nu,t}\}_{\nu=1}^{\bar{\nu}}$. However, his state is sufficiently characterized by the composite of capital services $\mathbf{k}_t$.

It is convenient to break the decision problem of a product market incumbent into two pieces: static and dynamic. The static part involves hiring labor and purchasing intermediate inputs in order to produce as well as competing in Cournot quantity competition for sales, taking the firm's state and input prices as given. The dynamic part deals with the decision whether to exit or to stay in the market and, conditional on staying, to choose investment for each capital variety.

The objective of the static problem is to maximize current period profits, given the firm and industry state which is denoted by $\omega_{it} \equiv (N_{it}, \{\mathbf{k}_{ijt}\}_{j=1}^{N_{it}})$:

$$\bar{\pi}(\mathbf{k}, \omega) = \max_{h, \{z_l\}_{l \neq i}^{I}} \left\{ p(\mathbf{y}_i) y_{ij} - w h_{ij} - \sum_{l \neq i}^{I} p_l z_{lij} \right\} \qquad \text{s.t. (2)},$$

where w is the economy-wide wage rate per unit of labor and $p(\mathbf{y_i})$ is the demand curve for the corresponding industry's total output produced by all incumbents: $\mathbf{y}_i = \sum_{j=1}^{N_i} y_{ij}$. The first-order conditions imply that the marginal revenue products equal factor costs

$$w = p_i \left[1 - \frac{1}{\epsilon_i(\mathbf{y}_i)} \frac{y_{ij}}{\mathbf{y}_i} \right] \cdot (1 - \alpha_i^k - \alpha_i^z) A_i \mathbf{k_{ij}}^{\alpha_i^k} \mathbf{z_{ij}}^{\alpha_i^z} h_{ij}^{-\alpha_i^k - \alpha_i^z} \tag{6}$$

(7) $$P_i^{\mathbf{z}} = p_i \left[1 - \frac{1}{\epsilon_i(\mathbf{y}_i)} \frac{y_{ij}}{\mathbf{y}_i}\right] \cdot \alpha_z A_i \mathbf{k_{ij}}^{\alpha_i^k} \mathbf{z_{ij}}^{\alpha_i^z - 1} h_{ij}^{1-\alpha_i^k-\alpha_i^z}$$

and demand relations for each intermediate variety z_l (by firm j in sector i) are given by:

(8) $$z_{ijl} = \theta_{l,i}^{\mathbf{z}} \cdot P_i^{\mathbf{z}} \mathbf{z}_{ij} / p_l \qquad \text{for all } l \neq i$$

where $\epsilon_i(\mathbf{y}_i) \equiv -\frac{\partial \mathbf{y}_i}{\partial p_i} \frac{p(\mathbf{y}_i)}{\mathbf{y}_i}$ is the price-elasticity of the industry demand curve and $P_i^{\mathbf{z}} = \prod_{l \neq i}^{I} \left(p_l / \theta_{l,i}^{\mathbf{z}}\right)^{\theta_{l,i}^{\mathbf{z}}}$ the price index for intermediate goods.

Since any industry's output is used as input by final good producers or as intermediate input by other industries, industry i's demand consists of final demand $y_i^f = \theta_i^Y \cdot Y/p_i$ and intermediate input demand $y_i^z = \sum_{l \neq i}^{I} \sum_{j=1}^{N_j} \theta_{l,i}^{\mathbf{z}} \cdot P_l^{\mathbf{z}} \mathbf{z}_{lj} / p_i$. Hence, the industry demand curves $p(\mathbf{y_i})$ are unit-elastic, i.e. $\epsilon_i(\mathbf{y}_i) = 1 \; \forall i = 1, ..., I$. As a result, maximized current period profits can be written as

(9) $$\bar{\pi} = \left(1 - (1 - \alpha_i^k) \left[1 - \frac{y_{ij}}{\mathbf{y}_i}\right]\right) p_i(\mathbf{y}_i) y_{ij}$$

The dynamic optimization problem is to maximize the value of a firm which enters period t with capital $\mathbf{k}$. This value consists of current period profits and the discounted future value net of investment if the incumbent decides to continue operating or an outside option value of zero if the incumbent exits the market:

(10) $$v(\mathbf{k}, \omega) = \bar{\pi}(\mathbf{k}, \omega) + \max\left(0, \max_{\{x_\nu\}_{\nu=1}^{\bar{\nu}}} \left\{-\sum_{\nu=1}^{\bar{\nu}} q_\nu \cdot x_\nu + \frac{1}{1+r'} v(\mathbf{k}', \omega')\right\}\right)$$

subject to the capital accumulation equations (5) and law of motion for the industry state: $\omega' = h_\omega(\omega)$. Here r denotes the real interest rate. The first-order conditions is

(11) $$k_\nu' = \theta_{\nu,i}^{\mathbf{k}} \cdot P_i^{\mathbf{k}} \mathbf{k}_i' / \frac{q_\nu}{\phi_\nu} \qquad \text{for all } \; \nu = 1, 2, ..., \bar{\nu}$$

and the envelope condition implies

(12) $$\frac{1}{1+r} \frac{\partial \bar{\pi}(\mathbf{k}', \omega')}{\partial \mathbf{k}'} = P_i^{\mathbf{k}}$$

where $P_i^{\mathbf{k}} = \prod_{\nu=1}^{\bar{\nu}} \left(\frac{q_\nu}{\phi_\nu \theta_{\nu,i}^{\mathbf{k}}}\right)^{\theta_{\nu,i}^{\mathbf{k}}}$ is the price index for the capital bundle. The incumbents' corresponding investment demand is derived from the capital accumulation equation (5):

$$x_{\nu,ij,t} = \theta^{\mathbf{k}}_{\nu,i} \cdot P^{\mathbf{k}}_i \mathbf{k}_{ij,t+1}/q_{\nu,t} - (1-\delta_\nu) \cdot k_{\nu,ij,t}/\phi_{\nu,t} \tag{13}$$

Investment demand is decreasing in the price q_ν and increasing in the quality level $\phi_{\nu,t}$. The latter effect reflects obsolescence of the existing capital stock.

Product market regulation and entry. Product industries are subject to governmental regulation raising barriers to entry. We focus on barriers to entry not only because they were common in the U.S. (e.g. licenses being a brute measure of entry regulation, red tape related to new business start-ups a more subtle one) but also because Blanchard and Giavazzi (2003) find them to be the regulatory measure crucial for the mode of industry competition. The reason is that entry regulation determines the number of firms operating in an industry and, thereby, their market power and profit margins. Entry costs are a convenient way of modeling entry regulation: a decrease in barriers to entry is a de-facto reduction of entry costs and it therefore mimics a deregulative measure. For example, cutbacks in regulations that require filing of reports and studies or stamps of approval will reduce the real resource cost of entry. A decline in license fees will have a similar effect from the entrant's perspective.[13]

We assume that there is free entry into the products market. Attempted entry is successful upon payment of entry costs which flow into the ocean. There is a pool of potential entrants which can choose to enter into any of the I industries upon paying a fixed setup cost. The cost of entry into industry i is denoted by $\kappa_{it} \geq 0$.[14] The process of entry takes a full period as investments need to be installed. The timing is as follows: an entering firm pays κ_{it} and purchases capital goods in period t; it starts operating in period $t+1$. Entry into a given industry takes place if:

$$-\kappa_{it} + \max_{x_{\nu,ie}} \left\{ -\sum_{\bar{\nu}} q_\nu \cdot x_{\nu,ie} + \frac{1}{1+r'} v(\mathbf{k}'_{ie}, \omega') \right\} \geq 0 \tag{14}$$

where

$$\mathbf{k}'_{ie} = \prod_{\nu=1}^{\bar{\nu}} \left(\phi_\nu \cdot x_{\nu,ie}\right)^{\theta^k_{\nu,i}}$$

In case of entry, the optimal capital stock is given by (12) and investments are determined

[13] If licence fees were refunded, a distinction might be sensible as Fang and Rogerson (2011) discuss.
[14] We assume that entry costs grow with the same rate as the economy does.

by:

$$x_{\nu,ie,t} = \theta^{\mathbf{k}}_{\nu,i} \cdot P^{\mathbf{k}}_i \mathbf{k}_{ie,t+1}/q_\nu \qquad \text{for all} \;\; \nu = 1, ..., \bar{\nu} \tag{15}$$

For future reference, we denote the number of entrants entering into industry i by N^E_i.

R&D firms. Each variety of capital ν is produced by a single R&D firm which is the sole producer of this variety. This firm can pursue R&D activities to increase the quality of its capital variety. These quality improvements result in endogenous investment-specific technical change: installing the current vintage of the capital good augments the corresponding capital stock by $\phi_{\nu,t}$ efficiency units.

More specifically, we assume a lab-equipment innovation possibilities frontier: quality $\phi_{\nu,t}$ is increasing in the firm's R&D spending $s_{\nu,t}$ (which is in terms of the final good).

$$\phi_{\nu,t} = \phi_{\nu,t-1} \cdot [1 + m_\nu \left(\frac{s_{\nu,t}}{\Omega_t}\right)^{\gamma_\nu}] \qquad m_\nu, \gamma_\nu > 0 \; \forall \; \nu \tag{16}$$

where γ_ν governs the returns to scale in R&D, m_ν scales the productivity of R&D, and Ω_t is a growth trend that eliminates scale effects.

Capital goods are sold to product market firms. Let $q_\nu(X_\nu)$ denote the aggregate inverse demand function for capital goods of variety ν where

$$X_{\nu,t} \equiv \sum_{i=1}^{I} N_{it} \cdot x_{\nu,ij,t} + N^E_{it} \cdot x_{\nu,ie,t} = \sum_{i=1}^{I} (N_i + N^E_i) \cdot \theta^{\mathbf{k}}_{\nu,i} \cdot P^{\mathbf{k}}_i \mathbf{k}_{ij,t+1}/q_\nu - (1-\delta_\nu)/\phi_{\nu,t} \cdot \sum_{i=1}^{I} N_i \cdot k_{\nu,ij,t}$$

is total investment demand for variety ν. As every variety is produced by a single R&D firm, these firms possess monopoly power in their corresponding sales markets.

The decision problem of any R&D firm involves choosing R&D activities and capital goods production in order to maximize profits. As the R&D firm is short-lived and will be replaced next period by some other R&D firm, its decision problem is static but consists of two stages: the first stage is to choose the optimal R&D investment strategy in order to improve the quality of its capital good. In stage two, the firm chooses a production quantity to maximize profits taking the quality level $\phi_{\nu,t}$ as given. The production of one unit of capital requires one unit of the final good. Hence, the stage-2 optimization problem of the firm is the following:

$$\bar{\pi}^R_\nu(\phi_{\nu,t}) \equiv \max_{q_{\nu,t}} \; \{[q_{\nu,t}(X_{\nu,t}) - 1] \cdot X_{\nu,t}(\phi_{\nu,t})\} \tag{17}$$

The first-order condition can be written as the usual markup-pricing rule over marginal costs (which are equal to 1)

$$q_{\nu,t} = \frac{1}{1 - \frac{1}{\epsilon_\nu(X_{\nu,t})}} \tag{18}$$

where the price elasticity of investment demand $\epsilon_\nu(X_\nu) \equiv -\frac{\partial X_\nu}{\partial q_\nu(X_\nu)} \frac{q_\nu}{X_\nu} = \frac{\sum_{i=1}^{I}(N_i + N_i^E) \cdot \theta_{\nu,i}^{\mathbf{k}} \cdot P_i^{\mathbf{k}} \mathbf{k}_{ij,t+1}}{q_\nu X_\nu}$ is determined by the corresponding nominal capital-investment ratio.

In the first stage, the firm chooses R&D to maximize profits net of R&D investment

$$\max_{s_{\nu,t}} \left\{ \bar{\pi}_\nu^R(\phi_{\nu,t}) - s_{\nu,t} \right\} \tag{19}$$

subject to the innovation possibility frontier (16) which governs the extent of quality improvement that is achieved by any chosen R&D level. The first-order condition can be written as

$$s_{\nu t} = [q_{\nu,t} - 1] X_{\nu,t}(\phi_{\nu,t}) \cdot \eta_{X_\nu,\phi_\nu} \cdot \eta_{\phi_\nu,s_\nu} \tag{20}$$

where $\eta_{X_\nu,\phi_\nu} \equiv \frac{\partial X_{\nu,t}(\phi_{\nu,t})}{\partial \phi_{\nu,t}} \frac{\phi_{\nu,t}}{X_{\nu,t}(\phi_{\nu,t})} = \frac{(1-\delta_\nu) \cdot \sum_{i=1}^{I} N_i \cdot k_{\nu,ij,t}}{\phi_{\nu,t} X_{\nu,t}}$ and $\eta_{\phi_\nu,s_\nu} \equiv \frac{\partial \phi_{\nu,t}}{\partial s_{\nu,t}} \frac{s_{\nu,t}}{\phi_{\nu,t}} = \gamma_\nu \frac{m_\nu (s_t/\Omega_t)^{\gamma_\nu}}{1 + m_\nu (s_t/\Omega_t)_t^{\gamma_\nu}}$ Hence, net profits are

$$\bar{\pi}_\nu^R - s_{\nu,t} = [1 - \eta_{X_\nu,\phi_\nu} \cdot \eta_{\phi_\nu,s_\nu}] \left[\frac{\epsilon_\nu(X_{\nu,t})}{\epsilon_\nu(X_{\nu,t}) - 1} - 1 \right] X_{\nu,t} \tag{21}$$

which are payed out to the household every period.

Household. The economy is populated by a infinitely-lived representative household that values consumption of the final good C and inelastically supplies L units of labor to the market sector. Labor is employed in the products sector and it is perfectly mobile across firms and industries. The objective of an individual is to maximize lifetime utility. Preferences are described by the following time-separable CIES utility function:

$$U = \sum_{t=0}^{\infty} \beta^t u(C_t) \qquad u(C_t) = \frac{C_t^{1-\sigma} - 1}{1 - \sigma} \tag{22}$$

where $\beta \in (0,1)$ is the personal discount factor and σ determines the intertemporal elasticity of substitution. The household earns wage and interest income. In addition, he receives a stream of distributed profits from R&D firms. The household chooses consumption to maximize his life-time utility (22) subject to his budget constraint:

$$C_t + A_{t+1} = w_t L + (1 + r_t)A_t + \Pi_t^R \tag{23}$$

where A denotes the household's asset holdings and $\Pi_t^R \equiv \sum_{\nu=1}^{\bar{\nu}} \bar{\pi}_{\nu,t}^R - s_{\nu,t}$ are the profits net of R&D spending of all R&D firms. The asset is a balanced portfolio of equity of all product market firms in all industries: $A_t = \sum_{i=1}^{I} N_{it} v_{ijt}$.

The household's optimality condition delivers the usual consumption-Euler equation:

$$\left(\frac{C_{t+1}}{C_t}\right)^{\sigma} = \beta\,(1 + r_{t+1}) \tag{24}$$

Having described the economic environment, we next turn to the equilibrium concept. Beforehand we briefly characterize the model's balanced growth path.

4.2 Balanced Growth Path and Stationary Transformation

Along a balanced growth path all variables grow at constant rates. Obviously, hours worked will remain constant while capital and output will grow in the presence of investment-specific technological change. The aggregate resource constraint implies that final output, consumption, investment, and R&D expenditures all have to grow at the same (gross) rate, say g. Similarly, the resource constraints for each product mean that output, final demand, and intermediate input demand grow at a common rate $g_{\mathbf{y}_i}$.

As the final good is assembled from intermediate products according to a Cobb-Douglas production function, the economy's growth rate is a weighted geometric mean of the industry growth rates: $g = \prod_{i=1}^{I} (g_{y_i})^{\theta_i^Y}$. Industry growth, in turn, is related to growth in capital services and intermediate inputs, as described by each industry's production function: $g_{y_i} = g_{\mathbf{k_i}}^{\alpha_i^k} g_{\mathbf{z_i}}^{\alpha_i^z}$. Again, due to the Cobb-Douglas functional form, growth in intermediate inputs and capital services, respectively, is a geometric mean of the growth rates of the corresponding components: $g_{z_i} = \prod_{l \neq i}^{I} (g_{z_l})^{\theta_l^{z_i}} = \prod_{l \neq i}^{I} (g_{y_l})^{\theta_l^{z_i}}$ and $g_{\mathbf{k}_i} = \prod_{\nu=1}^{\bar{\nu}} (g_{k_{\nu,i}})^{\theta_{\nu,i}^k}$. Recall that $k_{\nu,i}$ is the capital stock of variety ν, measured in efficiency units. Hence, its growth rate does not only reflect growth in physical investment but also investment-specific technical change: $g_{k_\nu} = g_{\phi_\nu} g$, as implied by the accumulation equation (5). Here, g_{ϕ_ν} denotes the rate of investment-specific technical change in the corresponding capital good. Note that the BGP growth rate of capital of variety ν is the same for all firms in all industries because each firm's investment grows at the same rate, g. Nevertheless, capital growth may differ across industries due to a varying composition of the capital stock: $g_{\mathbf{k}_i} = g_Y \cdot \prod_{\nu=1}^{\bar{\nu}} (g_{\phi_\nu})^{\theta^k_{\nu,i}}$.

Given these BGP growth rates, detrending variables by their balanced growth path will render them stationary. In the following we use a tilde to denote the stationary transformation of any variable: the stationary transformation of capital, for example, is denoted by $\tilde{\mathbf{k}}_t \equiv \mathbf{k}_t / g^t_{\mathbf{k}}$.

4.3 Equilibrium

Next, we consider a stationary symmetric Markov-perfect equilibrium of the decentralized economy. In a symmetric equilibrium all firms within an industry choose the same level of capital. Stationarity requires all variables to grow at constant rates. In other words, the economy follows a balanced growth path.

Stationary symmetric Markov-perfect equilibrium . *A stationary symmetric Markov-perfect equilibrium of the decentralized economy is represented by an allocation* $(\tilde{C}, \tilde{A}, \{\tilde{\mathbf{y}}_i, \tilde{\mathbf{z}}_i, h_i, \{\tilde{k}_{\nu,i}\}_{\nu=1}^{\bar{\nu}}\}_{i=1}^{I})$*, the number of product market firms in each industry* $\{N_i\}_{i=1}^{I}$*, and prices* $(\tilde{w}, r, \{p_i\}_{i=1}^{I}, \{q_\nu\}_{\nu=1}^{\bar{\nu}})$ *such that*

1. *the household solves his utility maximization problem given prices;*
2. *the final good firm solves its profit maximization problem given prices;*
3. *product market firms solve their profit maximization problems given input prices, industry demand curve, and competitors' quantities;*
4. *R&D firms solve their profit maximization problem given input prices and investment demand curve;*
5. *the number of product market firms in each industry is determined by free entry;*
6. *the laws of motion for the industry state* $\{h_\omega(\omega)\}_{i=1}^{I}$ *are consistent with number of product market firms operating in each industry* $\{N_i\}_{i=1}^{I}$.
7. *all markets clear:*
   (a) *labor*

$$L = \sum_{i=1}^{I} N_{it} h_{ijt} \tag{25}$$

(b) *final good*

(26) $$Y_t = C_t + X_t + S_t + E_t$$

where aggregate investment is $X_t = \sum_{\nu=1}^{\bar{\nu}} X_{\nu,t}$*, aggregate R&D spending is* $S_t = \sum_{\nu=1}^{\bar{\nu}} s_{\nu,t}$*, and total entry costs are* $E_t = \sum_{i=1}^{I} N_{it}^E \kappa_{it}$.

(c) *products*

(27) $$N_{it} y_{ijt} = \mathbf{y}_{it} = y_{it}^f + y_{it}^z \quad \forall\ i = 1, ..., I$$

(d) *capital goods*

(28) $$X_{\nu,t} = \sum_{i=1}^{I} N_{it} \cdot x_{\nu,ij,t} + N_{it}^E \cdot x_{\nu,ie,t} \quad \forall\ \nu = 1, ..., \bar{\nu}$$

(e) *asset*

(29) $$A_t = \sum_{i=1}^{I} N_{it} v_{ijt}$$

The model is solved numerically for its stationary equilibrium.

5 Quantitative Analysis

This section explores the model's ability to generate an acceleration of investment-specific technical change and a divergence in labor productivities as a result of product market deregulation. We begin with a discussion of our calibration strategy. Then, we introduce our quantitative experiment symbolizing the Ford/Carter deregulatory reforms and, finally, we present the findings.

5.1 Calibration

The model economy's balanced growth path is calibrated to match various stylized facts of the U.S. economy in the period 1960-75, that is, the pre-deregulation period. All parameters are listed in Table 3. Some parameters are set based upon a priori information from the literature. The intertemporal elasticity of substitution $1/\sigma$ is routinely set to 1/2 and the real interest rate to 4.5%. Both values are inserted into the Euler equation (24) to pin down the discount factor β.

Turning to the technology parameters, the elasticities of the Cobb-Douglas aggregators for the final good, the capital bundles, and the intermediate product bundles are pinned down by the corresponding cost shares in the data. The share of final demand in nominal output determines the elasticity of the final good aggregator: $\theta_i^Y = \frac{p_i y_i^f}{P^Y Y}$ for all 57 industries. We compute these shares of final demand in nominal output from the 1972 Input-Output tables published by the Bureau of Economic Analysis (Table 14). Furthermore, the Input-Output tables allow us to compute intermediate input shares $\theta_{l,i}^z = \frac{p_l y_l^{z_i}}{P^{z_i}\mathbf{z_i}}$. In the same way we compute the shares of all 27 capital goods we distinguish in the Current-Cost Net Stock of Private Fixed Assets by Industry from BEA's Fixed Asset Accounts $\theta_{\nu,i}^k = \frac{q_{\nu t}\cdot k_{\nu,i,t+1}/\phi_{\nu t}}{P_{i,t}^{\mathbf{k}}\cdot \mathbf{k_{i,t+1}}}$. Besides, we choose the depreciation rates δ_ν to target the investment-to-capital ratios $\frac{q_\nu \cdot x_\nu}{q_\nu \cdot k_{\nu,t}/\phi_{\nu,t-1}}$ for all 27 capital goods since both are related to each other through the capital accumulation equation (5).

The output elasticities of the production function have to be calibrated jointly with the number of firms by industry. In any industry all incumbent firms operate according the same production function. Hence, the incumbents' first-order conditions with respect to labor (6) and intermediate inputs (7) can be rearranged in order to target the industry's wage bill share and intermediate inputs share in industry's nominal gross output, respectively:

$$\left(1 - \frac{1}{N_i}\right)(1 - \alpha_i^k - \alpha_i^z) = \frac{wN_i h_{ij}}{N_i p_i y_{ij}} = \frac{wh_i}{p_i \mathbf{y}_i}$$

and

$$\left(1 - \frac{1}{N_i}\right)\alpha_i^z = \frac{\sum_{l\neq i}^I N_i p_l z_{li}}{N_i p_i y_{ij}} = \frac{P^{\mathbf{z_i}}\mathbf{z_i}}{p_i \mathbf{y}_i}$$

We compute these targets from the BEA's GDP by Industry Accounts. Finally, the industry total factor productivity parameters A_i are calibrated to match the statistic $\frac{p_i \mathbf{y}_i - P^{\mathbf{z_i}}\mathbf{z_i}}{\sum_i \mathbf{y}_i}$.

The R&D technology parameter γ_ν is chosen to match the pre-deregulation ISTC rate of the corresponding capital good reported by Cummins and Violante (2002) (Table 15 in the Appendix).[15]

Finally, the policy parameter entry costs are calibrated in the following way. In equi-

[15] Cummins and Violante (2002) provide ISTC rates for 26 capital goods covering equipment and software capital. For structures we follow the literature (e.g. Pakko, 2002c, 2005) and use the estimate of Gort, Greenwood, and Rupert (1999) who find an ISTC rate of 1% per year.

Table 3: Calibration

Parameter name	Symbol	Dim	Target
Preferences			
discount factor	β	1	r
intertemp. elasticity of substitution	$1/\sigma$	1	1
Production Technology			
elasticity of final good aggregator Y	θ_i^Y	I	$\frac{p_i y_i^f}{P^Y Y}$
elasticity of capital aggregator $\mathbf{k}$	$\theta_{\nu,i}^k$	$I \cdot \bar{\nu}$	$\frac{q_{\nu t} \cdot k_{\nu t+1}/\phi_{\nu t}}{\mu_{k,t} \cdot \mathbf{k_{t+1}}}$
elasticity of intermediate input aggregator $\mathbf{z}$	$\theta_{l,i}^z$	$I \cdot I$	$\frac{p_l y_l^{z_i}}{P^{z_i} \mathbf{z_i}}$
output elasticity w.r.t. capital	α_i^k	I	$\frac{\mathbf{w} h_i}{p_i \mathbf{y_i}}$
output elasticity w.r.t. intermediates	α_i^z	I	$\frac{P^{\mathbf{z_i}} \mathbf{z_i}}{p_i \mathbf{y_i}}$
industry TFP	A_i	I	$\frac{p_i \mathbf{y}_i - P^{\mathbf{z_i}} \mathbf{z_i}}{\sum_i \mathbf{y}_i}$
depreciation rate	δ_ν	$\bar{\nu}$	$\frac{q_\nu \cdot x_\nu}{q_\nu \cdot k_{\nu,t}/\phi_{\nu,t-1}}$
R&D Technology			
R&D duplication parameter	γ_ν	$\bar{\nu}$	g_{ϕ_ν}
R&D productivity parameter	m_ν	$\bar{\nu}$	1
Policy			
entry cost	κ_i	I	

librium, the free entry condition (14) imposes a positive relationship between entry costs and the value of a product market incumbent firm and, hence, an incumbent's current period profit contribution (9) which is negatively related to the number of incumbent firms operating in that industry. Hence, we calibrate the pre-deregulation level of entry costs by targeting the number of firms in each industry. However, we do not observe these data directly. But the County Business Patterns published by U.S. Census provide an annual series of the number of establishments by industry. We use this establishment data for 1975 to construct a target of the number of firms by industry as follows: firstly, we assume that the number of firms in each industry is proportional to the number of establishments reported in the County Business Patterns. Secondly, we calibrate this factor of proportionality in order to match a markup of 12% for the aggregate economy.

5.2 The Experiment

The purpose of the quantitative model is to answer the question "How much of the observed acceleration in investment-specific technical change is accounted for by U.S. product market deregulation?". We address this question by simulating two model economies. The first one matches important empirical facts of the U.S. economy in the pre-deregulation period (1960 - 1975), that is, before the Ford/Carter/Reagan reforms were implemented. The second model economy is a hypothetical one: how would the U.S. economy have looked like if product market regulations in the 1970s were at their post-deregulation levels. Comparing the change in ISTC rates of these model economies to the observed acceleration in actual U.S. data allows us to compute the fraction which is accounted for by deregulation in our model.

To this end, we decrease the entry costs for all 16 industries that have been deregulated under the Ford, Carter, and Reagan Administrations[16] by factor 5.[17] For all other industries which have not been subject to regulatory changes we assume that entry costs did not change.

[16]The deregulated industries are: Oil and gas extraction, Petroleum and coal products, Railroad transportation, Local and interurban passenger transit, Trucking and warehousing, Water transportation, Transportation by air, Pipelines, except natural gas, Transportation services, Telephone and telegraph, Radio and television, Electric services, Gas services, Depository institutions, Nondepository institutions, and Security and commodity brokers.

[17]On the one hand, Ebell and Haefke (2009) find that in the U.S. entry costs decreased by factor 9 between the late 1970s and late 1990s. On the other hand, our calibration of pre-deregulation entry costs suggests a factor of 2.5 between non-deregulated and deregulated industries. In the light of this evidence, factor 5 is an intermediate value for the extent of deregulation.

Table 4: Comparison of ISTC and labor productivity in the model and in the data

	U.S. economy			**Model economy**			**Fraction accounted for**
	pre-deregulation	post-deregulation	Δ	pre-deregulation	post-deregulation	Δ	
investment-specific technical change[a]							
aggregate	4.12	6.87	2.74	4.16	4.67	0.51	18.6%
de/regulated	3.78	7.32	3.54	4.20	6.70	2.50	70.6%
others	4.43	6.46	2.03	4.14	4.49	0.35	17.2%
labor productivity[b]							
aggregate	1.19	1.79	0.60	2.91	3.60	0.69	115.0%
de/regulated	1.55	5.07	3.52	2.92	4.04	1.12	31.8%
others	1.09	1.17	0.08	2.91	3.21	0.30	375.0%
Δ	0.46	3.90	3.44	0.01	0.83	0.82	23.8%

Pre-deregulation refers to the period 1960-75, post-deregulation to 1990-2000. The model panel shows BGP growth rates, the data panel average growth rates for the corresponding periods. Both are reported in percentage points per year. The last column computes the fraction of the observed acceleration in ISTC and labor productivity growth, respectively, that is accounted for by the deregulation experiment in the quantitative model (column 7 divided by column 4).

[a] The pre-deregulation period excludes ISTC rates for 1975 which are know to be an outlier (cf. Cummins and Violante, 2002, p. 257).

[b] Due to lacking data availability, the pre-deregulation period for labor productivity is 1978-1984 and the post-deregulation period is 1990-1997.

Data sources: Cummins and Violante (2002); Bureau of Economic Analysis, Historical Industry Accounts and Fixed Assets Accounts.

5.3 Findings

The results of the deregulation experiment are reported in Table 4. In the model, deregulation leads to an increase in the aggregate rate of ISTC from 4.2% to 4.7% per year. Comparing this acceleration of 0.5 percentage points to the observed acceleration of 2.7 percentage points means that the considered regulatory relief is able to explain about

18.6% of the acceleration of ISTC in the aggregate economy. However, focusing on the 16 deregulated industries only, deregulation is an important explanation for the acceleration of ISTC in deregulated industries. For these industries the policy experiment generates an acceleration of 2.5 percentage points, compared to 3.5 percentage points in the data. This means, 70.6% of the acceleration are accounted for by the quantitative model. For other industries, however, the model explains about one sixth of the observed acceleration in ISTC. One explanation for this might be that the model does not allow for a changing composition of the capital stock (in nominal terms) while the data suggests that a shift in investment towards high-ISTC capital goods contributes substantially to the acceleration of ISTC in non-deregulated industries. For example, the experiment explains five eighths of the increase in aggregate ISTC that is due to a pure asset-specific acceleration (0.8 percentage points, Table 2.B).

The quantitative model performs well in predicting a moderate rise in aggregate labor productivity growth as well as an almost constant growth rate for the non-deregulated industries. The 16 deregulated industries grew about 3.5 percentage points faster in the 1990s than before the reforms. Thus, the gap in labor productivity growth between deregulated and non-deregulated industries increased to the same extent. The quantitative model, however, captures only about one third of the rise in labor productivity growth of the deregulated industries. This suggests that gains in total factor productivity, maybe due to a reorganization of the production process, might be another important outcome of product market deregulation. Despite neglecting other sources of productivity growth than ISTC, the model is able to generate diverging labor productivities ensuing deregulation: the quantitative experiment still accounts for about a quarter of the observed divergence.

6 Concluding Remarks

Documenting that deregulated industries have outperformed the remaining U.S. economy in terms of labor productivity growth and investment-specific technical change, this paper studies industry and macroeconomic effects of competition policy. In particular, we address a quantitative question: to what extent can the Ford/Carter regulatory reforms account for the observed acceleration of ISTC and the subsequent divergence of labor productivity in the U.S.?

To this end, we develop a multi-sector general equilibrium model of endogenous ISTC that features imperfect competition and a technology choice by firms. In the model, industries are subject to governmental regulations which constitute barriers to entry. Deregulation is modelled as a reduction in entry barriers which results in new competitors entering deregulated industries. Intensified competition, in turn, leads to lower markups, declining prices, and expanding production. In order to increase output firms install additional capital goods. This rise in investment demand fosters R&D activities to improve the efficiency of capital goods and, hence, accelerates investment-specific technical change. Consequently, labor productivity grows at a higher rate.

We employ our model framework for a quantitative experiment. The experiment investigates the effects of the Ford/Carter reforms by simulating model economies calibrated to the U.S. economy with and without deregulation. We find that the quantitative model explains 70% of the observed acceleration in ISTC for the deregulated industries and almost a fifth of the overall acceleration for the U.S. economy. Furthermore, the deregulation experiment leads to a divergence of labor productivities across industries, as in the data. Deregulated industries grow substantially faster than the remaining U.S. economy. However, the simulations also suggest that a broad rise of asset-specific ISTC rates is not the only source. Rather, the figures leave some scope for investments being shifted towards high-ISTC assets, as the data for non-deregulated industries indicates. Beyond its role for ISTC, deregulation might have had important stimulating effects on total factor productivity, in addition. Both qualifications point to interesting directions of future research.

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A Industry-level evidence on the acceleration of ISTC

A.1 Dataset

Our empirical analysis inspects whether deregulation has indeed accelerated the pace of investment-specific technical change. To identify the causal impact of deregulation, we compare a panel of U.S. industries; some of them being directly affected by the Ford/Carter/Reagan reforms. We use industry-level data on the rate of ISTC computed by Cummins and Violante (2002). Constructed from a Tornqvist aggregation of asset-specific technology indexes, the industry-level indexes measure "the rate of technological improvement in the typical mix of investment goods used in production by each industry" (Cummins and Violante, 2002, p. 260).[18]

We classify the 62 industries covered by the Cummins and Violante (2002) dataset into two groups: deregultated versus non-deregulated industries.[19] Figure 5 shows the investment-share weighted mean for both groups as well as for the whole economy and reveals faster ISTC for deregulated industries. Note that the cross-industry variation in the rate of ISTC stems from the different composition of investment goods installed by each industry. The figure reveals that ISTC rates increased in the late 1950s and in the 1980s again. As we focus our analysis on the consequences of the Ford/Carter/Reagan deregulation, we restrict our estimation period to 1961-94 in order not to cover the Clinton deregulation period of the late 1990s.[20] As the vast majority of regulatory reforms was enacted in the years 1978 to 1982, we view this time span as the treatment epoch. Correspondingly, in our baseline specification the pre- and post-treatment period amount to 1961-77 and 1983-1994, respectively.

A.2 Empirical Strategy

The industry-level data allow us to compare the pace of technical change in deregulated industries with others not directly affected by the Ford/Carter/Reagan reforms. However, computing the causal effect of deregulation on the rate of ISTC would require data

[18]The Tornqvist aggregation method is described in Appendix C.1.1.

[19]Our classification is based upon the information on legislative and regulatory changes provided by Joskow and Noll (1994); Winston (1993). See Table 8 for details.

[20]The choice of 1961 as the first year under study is motivated by data issues: First, the underlying asset-specific ISTC rates are not available for computers and peripheral equipment and all three categories of software before 1960 in the Cummins and Violante (2002) dataset. Second, we regard the observations for 1959 and 1960 in the transportation by air industry with ISTC rates of more than 50% p.a. as outliers.

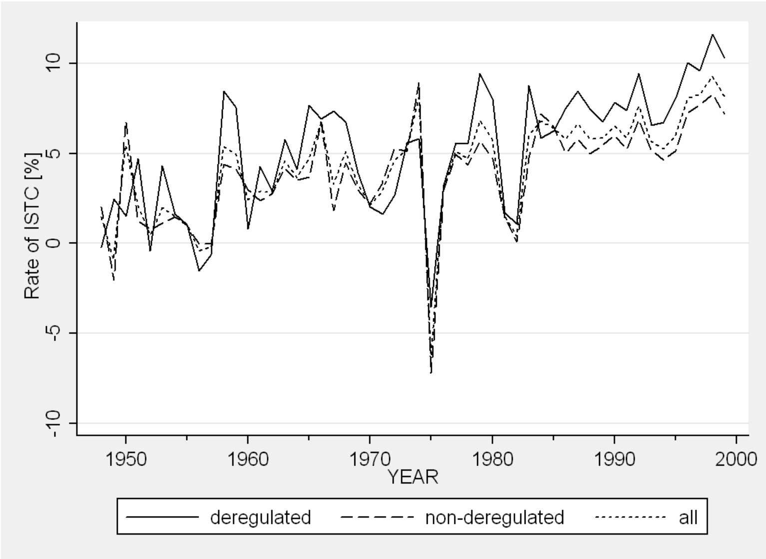


Figure 5: Rate of investment-specific technical change by regulation status

on an unobservable counterfactual situation: what would have been the pace of ISTC if deregulated industries had not been deregulated?

The econometric literature offers several estimators that make use of cross-sectional and/or longitudinal variation and employ different sets of assumptions to identify the average treatment effect of the treated.

1. The cross-sectional estimator:
   The cross-sectional estimator compares the rates of ISTC for deregulated industries to those of non-deregulated industries assuming that in absence of deregulation ISTC were the same across all industries. But if ISTC were faster (slower) for deregulated industries, the estimator would be biased upward (downwards).

2. The before-after estimator:
   The before-after estimator compares the rates of ISTC for deregulated industries before and after the policy change. This comparison is a valid estimate of the true causal effect only if the pace of ISTC would not have changed over time, had there not been the deregulative reforms. In the presence of a positive time trend, however, the causal effect is overestimated by the before-after estimator.

3. The difference-in-difference estimator:
   The difference-in-difference estimator allows for a time trend that is common for both

industry-groups by computing the difference of the before-after estimator between the deregulated and non-deregulated industries. The identifying assumption implicitly made here is that without any policy change, for both groups the change in ISTC rates would have been the same.

Of course, one can expect spillover effects from deregulated industries: even industries that were not directly affected by the regulatory reforms can benefit from higher quality equipment being available, although the R&D process has probably been more directed to the needs of the deregulated industries that increased their investment. In this case, both the cross-sectional and the difference-in-difference estimator underestimate the causal effect. Therefore, we regard them as a lower bound; and, hence, together with the before-after estimator the true causal effect of deregulation on investment-specific technical change is bracketed.

To implement these estimators on our (balanced) panel dataset, we estimate the average rate of ISTC in the period prior to and after the reforms for both groups. Thereto we regress the rate of ISTC, $q_{i,t}$, on dummy variables indicating the time period, $Post_t$, and regulatory status, $Dereg_i$, of industry i:

$$q_{i,t} = \alpha + \beta \cdot Post_t + \gamma \cdot Dereg_i + \delta \cdot (Post_t * Dereg_i) + \epsilon_{i,t}$$

where the coefficients β, γ and δ capture the before-after estimator, the cross-sectional estimator and the difference-in-difference estimator, respectively.

Given the panel structure of our dataset, independence of observations is unlikely: rather, the estimation strategy has to address the possibility of regression disturbances being correlated both over time and between industries. To the extent these correlations are due to unobservable common factors that are uncorrelated with the regressor, standard panel methods like pooled OLS or fixed effects still provide consistent coefficient estimates while standard error estimates are no longer valid. A popular remedy is to rely on "robust" standard errors, which are adjusted to be valid if certain assumptions regarding the model disturbances are violated: clustered standard errors, for instance, are valid if error terms can be assumed to be correlated only within the observational unit. The assumption of residuals being correlated within a cluster but independent across clusters is often inappropriate for panel models. Beck and Katz (1995) suggest panel corrected standard errors, which are robust to both contemporary cross-panel and serial correlation. Alternatively, one can apply a FGLS estimator with appropriate restrictions on the variance-covariance matrix.

A.3 Results

Table 5 reports the results for different specifications of pooled OLS and fixed effects regressions.[21] Among the pooled least squares estimates, we consider – besides a standard pooled OLS regression with clustered standard errors – a Prais-Winsten specification with panel-corrected standard errors as recommended by Beck and Katz (1995) as well as a feasible GLS model where the error process is allowed to be heteroskedastic across panels and assumed to follow a common AR(1) process. Finally, we employ a one-way error component regression model to allow for industry-specific fixed effects. While the first specification with clustered standard errors is equivalent to the pooled OLS estimator, the second within estimator explicitly models a common AR(1) error process.

The first column of Table 5, for instance, reports the results of the pooled OLS specification. In this case, the difference-in-difference estimator takes the value 1.312 percentage points p.a., the coefficient on the deregulation dummy estimates the cross-sectional estimator to be 1.342, and the before-after comparison yields an annual acceleration of 2.526 percentage points.[22]

To sum up, all specifications show a statistically significant and economically momentous increase of the ISTC rate. Except for the FGLS model, the difference-in-difference estimator, which yields a lower bound of the true causal effect, indicates an acceleration due to deregulation slightly above 1.3 percentage points p.a. . The cross-sectional estimates are in line with the difference-in-difference results. On the other hand, the before-after estimator offers an upper bound in the range of 2.5 to 2.7 percentage points.

Overall, the Cummins and Violante (2002) industry-level data provide empirical evidence of a 1.3 to 2.5 percentage point acceleration of investment-specific technical change caused by the Ford/Carter/Reagan deregulative reforms. Finally, our robustness checks confirm this finding. Extending the estimation period to the full sample slightly increases the causal effect (Table 10), while additionally classifying industries that were severely but only indirectly affected by the reforms as "deregulated" reduces it by about 0.4 percentage

[21] Random effects specifications have most often been rejected by a Hausman test.

[22] Note that the data is coded such that the coefficient on the interaction term of the post-treatment period with the deregulation dummy is identical to the difference-in-difference estimator, while the coefficients on the post-treatment period and the deregulation dummy are the before-after estimator and the cross-sectional estimator, respectively.

Table 5: Regression DiD: deregulated industries

	Pooled Least Squares			Industry Fixed Effects	
	OLS[a]	PRAIS-WINSTEN[b]	FGLS[c]	WITHIN[a, e]	WITHIN[d, e]
Explanatory	Estimate (Std. Err.)	Estimate (Std. Err.)	Estimate (Std. Err.)	Estimate (Std. Err.)	Estimate (Std. Err.)
dereg	1.342**	1.385***	0.842**		
	(0.592)	(0.415)	(0.420)		
d83	2.526***	2.697**	2.534***	2.526***	2.588***
	(0.536)	(1.059)	(0.511)	(0.536)	(0.413)
d83Xdereg	1.312**	1.345**	0.957*	1.312**	1.411***
	(0.580)	(0.551)	(0.557)	(0.579)	(0.465)
d7783	0.098	0.146	0.274	0.098	0.025
	(0.190)	(1.447)	(0.264)	(0.190)	(0.260)
d7783Xdereg	0.363	0.288	0.035	0.363	0.411
	(0.814)	(0.662)	(0.669)	(0.814)	(0.568)
_cons	6.694***	6.799***	6.224***	5.634***	5.663***
	(0.549)	(0.799)	(0.386)	(0.124)	(0.122)
R^2	0.038	0.027		0.046	0.037
χ^2		18.430	81.665		
F	11.858			14.710	19.186
p	0.0000	0.0025	0.0000	0.0000	0.0000
AC(1)			0.234		0.127
corr_fe				-0.109	-0.112
sigma_u				2.009	2.063
sigma_e				3.380	3.383
rho_fov				0.261	0.271
N_industries	62	62	62	62	62
Tbar		34	34	34	33
N	2108	2108	2108	2108	2046

[a] clustered standard errors reported
[b] Beck and Katz (1995) panel-corrected standard errors reported
[c] pooled FGLS with heteroskedastic errors following a common AR(1) process
[d] fixed effects model with common AR(1) error process
[e] within-R^2reported
estimation period: 1961-1994
significance level: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

points (Table 11). Moreover, the results are robust to different time frames of the interim, i.e. reform, period (Table 12).

A.3.1 Regulation Impact Regressions

The OECD indicator of regulation impact provides another way of robustness check: Instead of coding industries either as deregulated or not, the OECD indicator of regulation impact provides a measure of the extent of regulation impact. We regress the rate of ISTC on the OECD sectoral indicator of regulation impact. The dataset contains 27 industry groups for which the regulation impact (RI) indicator and the rate of ISTC can be matched.[23] Spanning from 1975 to 1999 it covers the Ford/Carter/Reagan and the Clinton deregulation.

Our hypothesis that deregulation has accelerated investment-specific technical change can be tested with a industry-fixed effects regression model. As the fixed-effects estimator relies solely on within variation, it captures only the impact of deviations of the regulation impact indicator from its time-mean on the rate of ISTC and discards the effect of cross-industry variation due to differing initial conditions. A negative relationship between the regulation impact indicator and the rate of ISTC will support our hypothesis, implying that more severe regulation is linked with lower technical change. As Table 6 shows for both the linear and the lin-log specification, the significantly negative coefficients confirm our hypothesis.

[23]As the OECD defines sectors according to the International Standard Industrial Classification (ISIC), concordance tables are used to match the industries. In this case, however, one has to considerably aggregate SIC industries to achieve correspondence.

Table 6: Regulation Impact Indicator Regression

	Industry Fixed Effects	
	WITHIN[a]	WITHIN[a]
Explanatory	Estimate (Std. Err.)	Estimate (Std. Err.)
regimp	-37.823*** (4.320)	
lnregimp		-8.812*** (1.041)
_cons	9.182*** (0.459)	-16.806*** (2.596)
within-R^2	0.066	0.096
F	76.646	71.613
corr	-0.919	-0.962
sigma_u	4.533	6.774
sigma_e	2.346	2.308
rho	0.789	0.896
N_industries	27	27
Tbar	24	24
N	648	648

[a] clustered standard errors reported
estimation period: 1975-1999
significance level: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

B Markup Estimation

B.1 Dataset

We use time-series data on value added and compensation of employees from the GDP-by-industry accounts published by the Bureau of Economic Analysis. The dataset is based on SIC industries and covers the period 1947 to 1997. Besides, we use the stock of private fixed assets and depreciation of private fixed assets from the BEA's Fixed Asset Accounts.[24] The literature computes the remuneration of capital as the product of a rental rate of capital and the capital stock. The rental rate of capital consists of an economic depreciation rate which is computed from FAA-data and the firms' real costs of funds rate. The latter is approximated by the nominal interest rate implied by Moody's AAA Corporate Bond index less inflation expectations. We follow Oliveira Martins, Scarpetta, and Pilat (1996) and construct our measure of inflation expectations as the HP-trend of the annual inflation rate, measured by a chain-type price-index for GDP.

[24]Tables 3.1ES and 3.4ES as of September 25, 2002.

B.2 Empirical Strategy

Roeger (1995) proposes to estimate the markup ratio of prices over marginal costs, $\mu \equiv \frac{P}{MC}$, indirectly via the Lerner index, $L \equiv \frac{P-MC}{P} \in [0,1]$. Employing primal and dual growth accounting, Roeger (1995) derives his estimation equation

$$\Delta y_t = L \cdot \Delta x_t + u_t \tag{30}$$

from a constant-returns-to-scale production function, $A_t \cdot F(N_t, K_t)$, for value added, Q_t, under imperfect competition. Here N_t and K_t denote labor and capital input, respectively, and A_t measures total factor productivity. Roeger (1995)'s dependent and explanatory variables are functions of these quantities and corresponding factor prices. Oliveira Martins, Scarpetta, and Pilat (1996) show that one can rearrange terms so that Δy_t and Δx_t are defined only by nominal variables:

$$\Delta y_t \equiv \Delta(q_t + p_t) - \alpha_t \cdot \Delta(n_t + w_t) - (1 - \alpha_t) \cdot \Delta(k_t + r_t)$$

$$\Delta x_t \equiv \Delta(q_t + p_t) - \Delta(k_t + r_t)$$

where P_t is the price of value added, W_t the wage rate, R_t the rental rate of capital, and $\alpha_t \equiv \frac{W_t N_t}{P_t Q_t}$ the wage bill share in value added. Lower-case letters denote logs of the corresponding (upper-case) variables. However, this regression may suffer from endogeneity issues as nominal value added appears on both sides of the estimation equation. Boulhol (2008); Hindriks, Nieuwenhuijsen, and de Wit (2000) argue that rearranging terms in the following way mitigates this bias:

$$\Delta x_t = \mu \cdot \Delta z_t + e_t \tag{31}$$

where

$$\Delta z_t \equiv \alpha_t \cdot [\Delta(n_t + w_t) - \Delta(k_t + r_t)]$$

As this regression estimates the markup directly, it is called the μ-based version, while Roeger (1995)'s original regression equation is called L-based version. Note that the relationship between both measures is non-linear: $\mu = \frac{1}{1-L}$. Boulhol (2008) shows theoretically that L-based markups are higher than μ-based ones.

Eventually, Oliveira Martins, Scarpetta, and Pilat (1996) show that in the presence of decreasing (increasing) returns to scale the estimated markup is upward-biased (downwardbiased). This finding is especially relevant in the case of fixed factors. As Boulhol (2008) points out, returns to scale on the variable factors matter. Hence, if capital, for example, were fixed in the short-run and returns to scale on the variable factors were decreasing, markups would be overestimated.

B.3 Results

We estimate markups by running μ-based regressions for 69 U.S. industries.[25] In order to bring out the impact of the Ford/Carter/Regan deregulation on market conduct, we split the sample into two estimation periods: a pre-deregulation period and a post-deregulation one. The regression results are illustrated in Figure 4 and condensed in Table 7.

Figure 4 compares the estimated gross markups for our benchmark period. Each bullet depicts a single industry. Bullets below the 45°-line indicate industries that experienced a decline in markup, while bullets above suggest an increase in markups. First of all, many estimates lie in the [1,2]-square. This means these markups are in a range of 0 to 100%, a very plausible order of magnitude. More importantly, most bullets are below the 45°-line which means that most US industries experienced a decline in the markup after the Carter/Reagan deregulation. This is particularly true for the majority of deregulated industries (red bullets).

Table 7 reports these markup estimates for a few industry groups. For the aggregate of deregulated industries, the gross markup decreased, on average, by 22 percentage points from 1.92 to 1.71. This decrease comes mainly from the Energy and Utilities industry as well as Radio and Television, as the industry-group estimates show. Similarly, markups in severely affected industries decline on average by 35 percentage points, while for the remaining private industries there is essentially no change. Overall, these findings indicate that deregulation lead to more intense competition in the 1980s and 1990s that becomes visible in lower markups.

[25] Table C.2.3 compares our μ-based and L-based estimates to Roeger (1995) as well as Oliveira Martins, Scarpetta, and Pilat (1996). By and large, our μ-based markups are close to Roeger (1995)'s estimates. Furthermore, for most of the industries that were not covered by Roeger (1995) or Oliveira Martins, Scarpetta, and Pilat (1996) our estimates seem to be plausible with respect to their order of magnitude.

Table 7: Estimation of Markup Ratios

Estimation Period	**1961 1977**	**1983 1994**	Δ	**1961 1974**	**1983 1997**	Δ
Private Industries	1.95	1.87	-0.08	2.06	1.87	-0.19
	(0.09)	(0.04)		(0.06)	80.04)	
Deregulated Industries	1.92	1.71	-0.22	1.95	1.76	-0.20
	(0.15)	(0.22)		(0.18)	(0.23)	
Energy and Utilities	3.00	1.07	-1.93	3.09	1.02	-2.06
	(0.35)	(0.90)		(0.38)	(0.88)	
Telecommunication	2.34	2.68	0.34	2.42	2.38	-0.04
	(0.19)	(0.57)		(0.19)	(0.56)	
Transportation	1.57	1.50	-0.06	1.52	1.51	-0.01
	(0.12)	(0.11)		(0.12)	(0.10)	
Radio and Television	1.95	1.06	-0.89	1.80	1.26	-0.55
	(0.21)	(0.77)		(0.21)	(0.66)	
Banking	1.57	1.70	0.14	1.58	1.75	0.17
	(0.10)	(0.18)		(0.11)	(0.18)	
Severely Affected Industries	2.35	2.00	-0.35	2.69	1.98	-0.70
	(0.22)	(0.33)		(0.20)	(0.32)	
Remaining Private Industries	1.92	1.90	-0.03	2.02	1.88	-0.13
	(0.10)	(0.05)		(0.06)	(0.05)	

Estimates for μ-based version of the regression equation.
White standard errors are reported in parentheses.

C Supplementary Materials

C.1 Data

C.1.1 Measuring Investment-specific Technical Change

The industry-level data on the rate of ISTC were constructed by Cummins and Violante (2002) from a Tornqvist aggregation of asset-specific technology indexes that are price-based measures of investment-specific technical change. To be precise, Cummins and Violante (2002) estimate for each of the 26 different categories of producers' durable equipment and software the quality bias implicit in the official NIPA price indexes. Correcting for this quality bias, they compute the (constant-quality) price of a investment good in terms of consumption, which the literature identifies with the inverse of the index of investment-specific technology. Then they aggregate for each of the 62 industries considered the asset-specific ISTC rates by weighting them according to their share in the industry's nominal investment expenditures. This yields a measure of *"the rate of technological improvement in the typical mix of investment goods used in production by each industry"* (Cummins and Violante, 2002, p. 260).

The investment data we use to aggregate the industry-specific ISTC rates into an index for deregulated and one for non-deregulated industries come from the U.S. Bureau of Economic Analysis' Fixed Asset Tables: Investment in Private Equipment and Software by Industry.

C.1.2 The OECD product market regulation index

Based on its International Regulation Database, the OECD compiles, among others, indicators of product market regulation at sectoral levels. According to Conway and Nicoletti (2006, p. 6) all indicators intend to "quantify the degree to which regulatory settings in a given sector are anti-competitive."

For sectors of the energy, transport and communication (ETCR) group, these indicators of sectoral regulation have been constructed for the years 1975 to 2007, while for retail distribution and business services (RBSR) sectors the indicators are only available for the years 1996, 1998, and 2003. Due to this data availability problem, we focus on the seven non-manufacturing sectors that have been under study since the mid-1970s, i.e. airlines, telecoms, electricity, gas, post, rail, and road freight.

Depending on the sector, some of the following low-level indicators have been computed: barriers to entry, public ownership, vertical integration, market structure, and price controls. Conway and Nicoletti (2006) claim that the coverage of the various regulatory areas is tailored to the structural characteristics of each industry.

These low-level indicators are constructed as weighted average of several items, each coded on a scale of 0 to 6, reflecting increasing restrictiveness of regulatory provisions to competition. Scores are awarded relative to theoretical best or worst practice situations. In order to obtain indicators by area of regulation, low-level indicators are aggregated across sectors using some weighting scheme.

The Barriers to Entry Indicator covers regulations that curb entry and/or distort market structure relative to a competitive outcome (Conway and Nicoletti, 2006, p. 7). It is therefore closest to our question at hand. The indicator consists of 2 to 4 equally weighted items and collects information on the extent to which the number of firms that are allowed to operate in a market is restricted and on the legal conditions of entry into the market; for the energy sector information on the terms and conditions of third party market access and on the extent of choice of supplier for consumers instead.

C.1.3 Classifying Deregulated Industries

For the classification of industries into deregulated or non-deregulated we collect information on legislative and regulatory changes during the Ford, Carter, and Reagan presidencies. Our classification is based upon Joskow and Noll (1994, tab. 6.2) and Winston (1993, tab. 1) and shown in the third column of Table 8.

Moreover, the OECD Indicators of Regulation Impact (Conway and Nicoletti, 2006) allow us to identify industries that were not directly hit by the deregulative reforms but were affected indirectly via economic linkages to deregulated ones.[26] We define an industry to be severely affected by deregulation if its Regulatory Impact indicator declined by more than 10% between 1978 and 1982. These industries are marked in the last column of Table 8.

[26] OECD Indicators of Regulation Impact are available from the OECD International Regulation Database at `http://www.oecd.org/document/1/0,3343,en_2649_34323_2367297_1_1_1_1,00.html`.

Table 8: Coding of deregulation dummy

US SIC	Industry	year of earliest deregulative reform	severely affected industries
1	Farms		x
7	Agricultural services, forestry, and fishing		x
10	Metal mining		
12	Coal mining		
13	Oil and gas extraction	1978	
14	Nonmetallic minerals, except fuels		
15	Construction		
20	Food and kindred products		
21	Tobacco products		
22	Textile mill products		
23	Apparel and other textile products		
24	Lumber and wood products		x
25	Furniture and fixtures		
26	Paper and allied products		
27	Printing and publishing		
28	Chemicals and allied products		
29	Petroleum and coal products	1981	
30	Rubber and miscellaneous plastics products		x
31	Leather and leather products		
32	Stone, clay, and glass products		x
33	Primary metal industries		x
34	Fabricated metal products		
35	Industrial machinery and equipment		
36	Electronic and other electric equipment		
371	Motor vehicles and equipment		
372	Other transportation equipment		
38	Instruments and related products		
39	Miscellaneous manufacturing industries		
40	Railroad transportation	1976	x
41	Local and interurban passenger transit	1982	x
42	Trucking and warehousing	1980	x
44	Water transportation	1984	x
45	Transportation by air	1978	x
46	Pipelines, except natural gas	1981	x
47	Transportation services	1980	x

Continued on next page

Table 8: Coding of deregulation dummy

US SIC	**Industry**	**year of earliest deregulative reform**	**severely affected industries**
481	Telephone and telegraph	1977	
483	Radio and television	1981	
491	Electric services	1978	
492	Gas services	1981	
495	Sanitary services		
50	Wholesale trade		
52	Retail trade		
60	Other depository institutions	1980	
6011	Federal reserve banks		
61	Nondepository institutions	1980	
62	Security and commodity brokers	1975	
63	Insurance carriers		
64	Insurance agents, brokers, and service		
65	Real estate		
671	Nonfinancial holding and investment offices		
672	Financial holding and investment offices		
70	Hotels and other lodging places		
72	Personal services		
73	Business services		
75	Auto repair, services, and parking		
76	Miscellaneous repair services		
78	Motion pictures		
79	Amusement and recreation services		
80	Health services		
81	Legal services		
82	Educational services		
83	Other services, n.e.c.		

Industries classified as "severely affected by deregulative reform" are defined by a decline of the OECD Regulatory Impact indicator by more than 10% between 1978 and 1982.
Industries classified as "deregulated" or "highly affected by deregulative reform" are coded as 0, others as -1.

C.2 Tables and Figures Appendix

C.2.1 Acceleration of Investment-specific technical change

It is a well-documented fact that ISTC accelerated in the early 1980s. Table 9 provides an overview of the empirical evidence. Note that there exist, essentially, two different measures of the state of investment-specific technology: first, both Cummins and Violante (2002) and Pakko (2002b) provide time-series data on the development of investment-specific technology indices, which are derived from a constant-quality price index for investment goods based on Gordon (1990)'s "The Measurement of Durable Goods Prices". Second, the Bureau of Economic Analysis started to introduce hedonic methods only in the late 1980s and 1990s.[27]

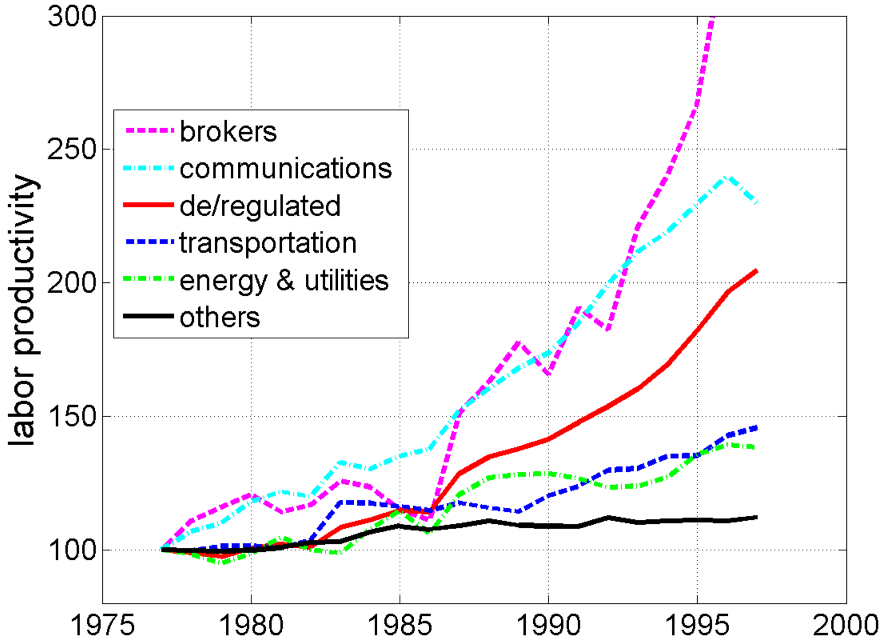
As expected, both the growth rates of investment-specific technology and their increase show some variation, depending not only on the data source and periods considered but also the definition of investments employed. A closer look at the varieties of investments establishes the following pattern: ISTC is especially prominent in computers, communication equipment, and software – sometimes at two-digit rates –, while other types of producers' durable equipment and structures show lower rates.[28] Nevertheless, all report an economically significant acceleration, mostly in the range between 1.5 to 2.5 percentage points p.a. . Regarding the timing of the acceleration, Pakko (2005, Tab. 1) conducts statistical structural-break tests and provides overwhelming evidence for a breakpoint in 1983 – just about the end of the deregulation phase.

C.2.2 Robustness of DiD results

[27]see e.g. Pakko (2002a) or Pakko (2005, Appendix).

[28]ISTC rates for different asset categories are reported by Cummins and Violante (2002) and Pakko (2002a, Web appendix). In order to evaluate their contribution to productivity growth, Martínez, Rodríguez, and Torres (2010); **?** conduct decomposed growth accounting.

Figure 6: Labor productivity diverges



Notes: Labor productivity is computed as real value-added per full-time equivalent employee. De/regulated industries are Energy and utilities, Communications, Transportation, and Brokers; affected industries are those private industries that obtained more than 20 % of their intermediate inputs from de/regulated industries; other industries are all remaining private industries.
Data Source: Bureau of Economic Analysis, NIPA.

Table 9: Rise in Investment-Specific Technical Change

article	**aggregation of investments**	**data source**	**growth in ISTC p.a.**	
			period 1	**period 2**
GY (1997)	producers' durable equipment	Gordon, NIPA	1954-74: 3.3%	1975-1990: 4.0%
KORV (2000)	capital equipment	Gordon	1963-79: 3.6%	1980-1992: 6.0%
KORV (2000)	capital equipment	NIPA	1963-79: 0.3%	1980-1992: 2.6%
CV (2002)	equipment & software	CV	1960-79: 3.6%	1980-2000: 5.5%
Fisher (2006)	equipment & software	CV	1955-82: 3.2%	1983-2000: 5.8%
RT (2012)	equipment & software	CV, RT	1977-80: 2.6%	1980-1990: 5.5%
Pakko (2002c)	total private NFI[a]	Pakko	1950-82: 2.0%	1983-2000: 4.0%
Pakko (2005)	total private NFI[a]	Pakko	1951-87: 2.2%	1988-2001: 3.8%
JPT (2009)	consumer durables & PDI[b]	CV	1954-81: 1.2%	1982-2000: 3.1%
JPT (2009)	consumer durables & PDI[b]	NIPA	1954-81: 0.6%	1982-2000: 2.4%

[a] NFI: nonresidential fixed investment
[b] PDI : private domestic investment
GY (1997): Greenwood and Yorukoglu (1997)
KORV (2000): Krusell, Ohanian, Ríos-Rull, and Violante (2000)
CV (2002): Cummins and Violante (2002)
RT (2012): **?**
JPT (2009): Justiniano, Primiceri, and Tambalotti (2009)

Table 10: Regression DiD: deregulated industries, all years

	Pooled Least Squares			Industry Fixed Effects	
	OLS[a]	Prais-Winsten[b]	FGLS[c]	Within[a, e]	Within[d, e]
Explanatory	Estimate (Std. Err.)	Estimate (Std. Err.)	Estimate (Std. Err.)	Estimate (Std. Err.)	Estimate (Std. Err.)
dereg	1.416**	1.454***	0.976***		
	(0.655)	(0.474)	(0.373)		
d83	3.935***	4.083***	3.667***	3.925***	3.897***
	(0.460)	(0.919)	(0.437)	(0.457)	(0.373)
d83Xdereg	1.352***	1.407**	1.003**	1.342***	1.258***
	(0.494)	(0.599)	(0.471)	(0.491)	(0.420)
d7783	1.104***	1.062	0.953***	1.104***	1.047***
	(0.246)	(1.330)	(0.246)	(0.246)	(0.270)
d7783Xdereg	0.329	0.282	0.235	0.319	0.157
	(0.767)	(0.837)	(0.659)	(0.772)	(0.589)
_cons	7.130***	7.239***	6.634***	6.010***	6.075***
	(0.607)	(0.728)	(0.346)	(0.106)	(0.105)
R^2	0.110	0.078		0.125	0.088
χ^2		25.154	302.724		
F	60.298			75.388	74.417
p	0.0000	0.0001	0.0000	0.0000	0.0000
AC(1)			0.240		0.215
corr_fe				-0.090	-0.084
sigma_u				1.624	1.641
sigma_e				3.547	3.479
rho_fov				0.173	0.182
N_industries	62	62	62	62	62
Tbar		51.97	51.97	51.97	50.97
N	3222	3222	3222	3222	3160

[a] clustered standard errors reported
[b] Beck and Katz (1995) panel-corrected standard errors reported
[c] pooled FGLS with heteroskedastic errors following a common AR(1) process
[d] fixed effects model with common AR(1) error process
[e] within-R^2reported
estimation period: 1948-1999
significance level: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 11: Regression DiD: deregulated and severely affected industries

	Pooled Least Squares			Industry Fixed Effects	
	OLS[a]	PRAIS-WINSTEN[b]	FGLS[c]	WITHIN[a, e]	WITHIN[d, e]
Explanatory	Estimate (Std. Err.)	Estimate (Std. Err.)	Estimate (Std. Err.)	Estimate (Std. Err.)	Estimate (Std. Err.)
dereg	0.018	0.036	-0.457		
	(0.517)	(0.359)	(0.329)		
d83	2.124***	2.269**	2.117***	2.124***	2.191***
	(0.365)	(1.121)	(0.365)	(0.365)	(0.325)
d83Xdereg	0.960**	0.971**	0.560	0.960**	1.085***
	(0.447)	(0.476)	(0.436)	(0.447)	(0.400)
d7783	0.157	0.187	0.298	0.157	0.055
	(0.210)	(1.428)	(0.288)	(0.210)	(0.285)
d7783Xdereg	0.052	0.052	-0.087	0.052	0.169
	(0.562)	(0.574)	(0.525)	(0.562)	(0.489)
_cons	5.646***	5.725***	5.198***	5.634***	5.663***
	(0.461)	(0.846)	(0.275)	(0.125)	(0.123)
R^2	0.039	0.028		0.045	0.037
χ^2		15.594	98.946		
F	13.268			15.215	18.767
p	0.0000	0.0081	0.0000	0.0000	0.0000
AC(1)			0.227		0.127
corr_fe				-0.002	-0.003
sigma_u				1.925	1.975
sigma_e				3.382	3.385
rho_fov				0.245	0.254
N_industries	62	62	62	62	62
Tbar		34	34	34	33
N	2108	2108	2108	2108	2046

[a] clustered standard errors reported
[b] Beck and Katz (1995) panel-corrected standard errors reported
[c] pooled FGLS with heteroskedastic errors following a common AR(1) process
[d] fixed effects model with common AR(1) error process
[e] within-R^2 reported
estimation period: 1961-1994
significance level: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 12: Regression DiD: deregulated industries, interim period

pre reform	1961 - 1979		1961 - 1976		1961 - 1974	
post reform	1980 - 1994		1983 - 1994		1985 - 1994	
	PRAIS-WINSTEN[b]	WITHIN[a, c]	PRAIS-WINSTEN[b]	WITHIN[a, c]	PRAIS-WINSTEN[b]	WITHIN[a, c]
Explanatory	Estimate (Std. Err.)	Estimate (Std. Err.)	Estimate (Std. Err.)	Estimate (Std. Err.)	Estimate (Std. Err.)	
dereg	1.068***		1.385***		1.363***	
	(0.398)		(0.415)		(0.466)	
d80	1.208	1.402***				
	(1.044)	(0.510)				
d80Xdereg	0.895*	1.037*				
	(0.527)	(0.548)				
d83			2.697**	2.526***		
			(1.059)	(0.536)		
d83Xdereg			1.345**	1.312**		
			(0.551)	(0.579)		
d7783			0.146	0.098		
			(1.447)	(0.190)		
d7783Xdereg			0.288	0.363		
			(0.662)	(0.814)		
d85					1.291	1.730***
					(1.180)	(0.593)
d85Xdereg					1.365**	1.310**
					(0.613)	(0.629)
d7585					-2.196*	-1.426***
					(1.259)	(0.188)
d7585Xdereg					0.567	0.367
					(0.601)	(0.780)
const	5.809***	5.027***	6.799***	5.634***	6.512***	5.588***
	(0.789)	(0.107)	(0.799)	(0.124)	(0.898)	(0.131)
R^2	0.002	0.011	0.027	0.046	0.047	0.059
χ^2	8.415		18.430		14.989	
F		5.449		14.710		27.369
p	0.0382	0.0229	0.0025	0.0000	0.0104	0.0000
corr_fe		-0.129		-0.109		-0.104
sigma_u		1.988		2.009		2.013
sigma_e		3.440		3.380		3.356
rho_fov		0.250		0.261		0.265
N_industries	62	62	62	62	62	62
Tbar	34	34	34	34	34	34
N	2108	2108	2108	2108	2108	2108

[a] clustered standard errors reported
[b] Beck and Katz (1995) panel-corrected standard errors reported
[c] within-R^2 reported
significance level: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

C.2.3 Markup Estimation

Table 13: Comparison of Markups for the U.S.

	Roeger (1995)	Oliveira Martins et al. (1996)	L-based			μ-based		
Period	1953 - 1984	1970 - 1992	1953 - 1984			1953 - 1984		
Industry	Markup	Markup	Markup	95% CI (White)		Markup	95% CI (White)	
Private industries			2.01	1.89	2.14	1.95	1.83	2.08
Agriculture, forestry, and fishing			15.85	9.78	41.82	4.59	1.03	8.15
Farms			23.80	12.55	231.27	4.81	0.74	8.89
Agricultural services, forestry, and fishing			2.66	2.38	3.03	2.36	2.15	2.57
Mining			6.42	3.47	42.47	1.78	0.43	3.13
Metal mining			4.74	3.46	7.52	2.30	1.25	3.34
Coal mining			3.14	1.77	13.77	1.33	1.03	1.62
Oil and gas extraction			12.41	6.64	94.63	3.81	1.75	5.87
Nonmetallic minerals, except fuels			3.09	2.54	3.95	2.42	1.96	2.87
Construction	1.44		1.55	1.40	1.73	1.50	1.35	1.64
Manufacturing			1.62	1.51	1.75	1.55	1.39	1.70
Durable goods	1.45		1.60	1.47	1.75	1.51	1.37	1.66
Lumber and wood products	1.75	1.22	2.06	1.89	2.26	1.94	1.77	2.11
Furniture and fixtures	1.28	1.06	1.34	1.18	1.56	1.23	1.03	1.43
Stone, clay, and glass products	1.59	1.09 - 1.18	1.90	1.68	2.18	1.76	1.53	1.99
Primary metal industries	1.58	1.10 - 1.14	1.99	1.74	2.33	1.70	1.47	1.93
Fabricated metal products	1.33	1.09	1.39	1.29	1.49	1.33	1.21	1.45
Machinery, except electrical	1.41	1.06 - 1.54	1.50	1.36	1.66	1.39	1.24	1.55
Electric and electronic equipment	1.34		1.49	1.31	1.73	1.33	1.10	1.56
Motor vehicles and equipment	2.06	1.09	2.48	2.09	3.04	2.00	1.63	2.37
Other transportation equipment	1.22	1.05 - 1.13	1.78	1.12	4.32	1.13	0.92	1.33
Instruments and related products	1.47	1.09	1.60	1.35	1.95	1.38	1.13	1.64
Miscellaneous manufacturing industries	1.62	1.08	1.75	1.42	2.30	1.19	0.81	1.56
Nondurable goods	1.48		1.72	1.57	1.89	1.61	1.41	1.82
Food and kindred products	1.50	1.05	2.25	1.71	3.27	1.51	1.13	1.90
Tobacco products	2.75	1.56	7.35	6.01	9.46	6.13	5.39	6.87
Textile mill products	1.34	1.08	1.43	1.31	1.56	1.36	1.26	1.46
Apparel and other textile products	1.15	1.10	1.25	1.13	1.38	1.15	1.02	1.27
Paper and allied products	1.57	1.13	1.77	1.59	2.00	1.65	1.48	1.82
Printing and publishing	1.40	1.19	1.66	1.48	1.89	1.52	1.32	1.72
Chemicals and allied products	2.11	1.18 - 1.44	2.67	2.27	3.25	2.06	1.71	2.41
Petroleum and coal products		1.11	9.63	5.28	54.31	2.27	0.84	3.70
Rubber and miscellaneous plastics products	1.36		1.61	1.42	1.85	1.46	1.22	1.70

	Roeger (1995)	Oliveira Martins et al. (1996)	L-based			μ-based		
	Markup	Markup	Markup	95% CI (White)		Markup	95% CI (White)	
Leather and leather products	1.19	1.08	1.30	1.14	1.50	1.12	0.96	1.28
Transportation and public utilities			2.16	1.89	2.51	1.99	1.77	2.22
Transportation			1.68	1.50	1.92	1.60	1.43	1.77
Railroad transportation			1.61	1.37	1.97	1.41	1.20	1.62
Local and interurban passenger transit			1.96	1.65	2.42	1.62	1.47	1.78
Trucking and warehousing			1.56	1.45	1.69	1.49	1.38	1.59
Water transportation			1.51	1.26	1.87	1.26	1.02	1.51
Transportation by air			2.14	1.85	2.55	1.82	1.58	2.07
Pipelines, except natural gas			10.90	8.05	16.88	4.97	3.09	6.85
Transportation services			4.46	2.96	9.03	1.89	1.08	2.71
Communications			2.55	2.14	3.16	2.11	1.83	2.39
Telephone and telegraph			2.69	2.21	3.44	2.14	1.82	2.46
Radio and television		1.40	2.10	1.83	2.47	1.78	1.55	2.01
Electric, gas, and sanitary services	3.14		3.84	3.36	4.48	3.22	2.68	3.76
Wholesale trade			2.19	1.98	2.44	2.01	1.85	2.17
Retail trade			1.91	1.77	2.08	1.82	1.66	1.98
Finance, insurance, and real estate			5.01	4.62	5.47	4.83	4.47	5.19
Banking			2.47	2.19	2.82	2.14	1.84	2.44
Credit agencies other than banks			9.18	3.76	∞	1.04	0.20	1.88
Security and commodity brokers			2.10	1.69	2.77	1.62	1.37	1.87
Insurance carriers			1.76	1.51	2.11	1.48	1.27	1.68
Insurance agents, brokers, and service			2.72	2.37	3.21	2.26	1.85	2.67
Real estate			23.02	18.81	29.64	17.12	14.95	19.30
Services			1.73	1.63	1.84	1.68	1.58	1.78
Hotels and other lodging places			2.01	1.84	2.22	1.88	1.68	2.08
Personal services			1.93	1.77	2.13	1.82	1.66	1.98
Business services			1.67	1.54	1.81	1.53	1.41	1.65
Auto repair, services, and parking			2.89	2.40	3.65	2.21	1.69	2.73
Miscellaneous repair services			2.77	2.22	3.67	1.98	1.54	2.43
Motion pictures			2.55	2.09	3.27	1.83	1.40	2.26
Amusement and recreation services			2.30	1.96	2.77	2.00	1.79	2.21
Health services			2.09	1.69	2.74	1.37	1.03	1.70
Legal services			3.47	2.89	4.35	2.37	1.74	3.00
Educational services			1.07	1.02	1.13	1.05	0.99	1.11
Other			1.19	1.13	1.25	1.17	1.11	1.23

C.3 Calibration

Table 15: Average annual rate of ISTC by capital good

	Capital Type	ISTC rate	
		1960-75	1965-75
1	Computers and peripheral equipment	26.083	23.475
2	Pre-Packaged software	17.146	15.767
3	Customized software	0.512	0.971
4	Own-account software	4.386	4.440
5	Communication equipment	3.234	3.766
6	Instruments, photocopy, and related equipment	6.957	9.332
7	Office and accounting equipment	2.667	3.349
8	Fabricated metal products	2.769	2.262
9	Engines and turbines	3.117	2.126
10	Metalworking machinery	1.260	1.644
11	Special industry machinery	3.874	4.040
12	General industrial equipment	2.430	2.150
13	Electrical transmission, distribution, and industrial apparatus	4.316	2.877
14	Trucks, buses, and truck trailers	4.057	4.252
15	Autos	4.031	5.472
16	Aircraft	10.752	10.893
17	Ships and boats	2.199	1.933
18	Railroad equipment	1.538	2.216
19	Furniture and fixtures	1.871	1.644
20	Tractors	1.808	2.420
21	Agricultural machinery	0.092	0.122
22	Construction machinery	2.196	1.900
23	Mining and oilfield machinery	2.196	1.900
24	Service industry machinery	5.451	5.221
25	Electrical equipment	1.746	1.839
26	Other equipment	2.424	2.355
27	Structures	1.000	1.000

Sources: For equipment and software capital the underlying data is taken from the web appendix to Cummins and Violante (2002). For structures we use the estimate of Gort, Greenwood, and Rupert (1999) which we assume to be valid for the whole post-war period.

Table 14: Calibrated share in final demand

	Industry	θ_i^Y [%]
1	FARMS	1.10419
2	AGRICULTURAL SERVICES, FORESTRY, FISHING	0.09339
3	METAL MINING	0.02490
4	COAL MINING	0.02205
5	OIL & GAS EXTRACTION	0.06561
6	NONMETALLIC MINERALS, EXCEPT FUELS	0.00291
7	CONSTRUCTION	10.59149
8	LUMBER AND WOOD PRODUCTS	0.11373
9	FURNITURE AND FIXTURES	0.99012
10	STONE, CLAY, AND GLASS PRODUCTS	0.17679
11	PRIMARY METAL INDUSTRIES	0.13412
12	FABRICATED METAL PRODUCTS	0.61937
13	INDUSTRIAL MACHINERY	3.24991
14	ELECTRICAL MACHINERY	2.33676
15	MOTOR VEHICLES AND EQUIPMENT	4.82430
16	OTHER TRANSPORTATION EQUIPMENT	1.38573
17	INSTRUMENTS AND RELATED PRODUCTS	0.78747
18	MISCELLANEOUS MANUFACTURING	0.87027
19	FOOD AND KINDRED PRODUCTS	7.79307
20	TOBACCO PRODUCTS	0.67382
21	TEXTILE MILL PRODUCTS	0.78039
22	APPAREL & OTHER TEXTILE PRODUCTS	2.36554
23	PAPER AND ALLIED PRODUCTS	0.30183
24	PRINTING AND PUBLISHING	0.65215
25	CHEMICALS AND ALLIED PRODUCTS	1.38040
26	PETROLEUM AND COAL PRODUCTS	1.40795
27	RUBBER AND PLASTIC PRODUCTS	0.54685
28	LEATHER AND LEATHER PRODUCTS	0.55120
29	RAILROAD TRANSPORTATION	0.33863
30	LOCAL AND INTERURBAN TRANSIT	0.44804
31	TRUCKING AND WAREHOUSING	0.80221
32	WATER TRANSPORTATION	0.13292
33	AIR TRANSPORTATION	0.60672
34	PIPELINES, EXCEPT NATURAL GAS	0.03127
35	TRANSPORTATION SERVICES	0.03540
36	TELEPHONE AND TELEGRAPH SERVICES	1.60874
37	RADIO & TV BROADCASTING	0.00778
38	ELECTRIC SERVICES	1.30755
39	GAS SERVICES	0.67403
40	SANITARY SERVICES	0.13031
41	WHOLESALE TRADE	4.89388
42	RETAIL TRADE	15.11415
43	DEPOSITORY INSTITUTIONS	1.33678
44	NONDEPOSITORY INSTITUTIONS	0.38531
45	SECURITY AND COMMODITY BROKERS	0.40867
46	INSURANCE CARRIERS	2.04622
47	INSURANCE AGENTS AND BROKERS	0.00000
48	REAL ESTATE	12.07569
49	HOTELS AND LODGING PLACES	0.51125
50	PERSONAL SERVICES	1.69478
51	BUSINESS SERVICES	0.40354
52	AUTO REPAIR, SERVICES, AND PARKING	1.46024
53	MOTION PICTURES	0.16037
54	AMUSEMENT AND RECREATION SERVICES	0.73559
55	HEALTH SERVICES	4.95109
56	LEGAL SERVICES	0.57186
57	EDUCATIONAL SERVICES	1.07725
58	OTHER SERVICES	2.20339