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The Role of Regulation and Taxes in US Capital and Labor Input Use

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Abstract
This paper uses revised and extended data on federal regulation and marginal tax rates to provide a closer look than previous studies at how these policy variables affect the mix of inputs used in the US economy. Time-series models for labor and physical capital inputs indicate that regulation and taxes alter the time paths of both inputs, with a positive tax effect dominating the movement of labor and a negative regulation effect dominating for capital. In terms of the mix of inputs used in production, the combined effects of changes in tax rates and regulation since 1949 reduced the level of capital per worker by more than 50 percent through 2016.

JEL Codes: E23, H20, L50
Keywords: regulation, taxes, aggregate production, capital, labor

I. Introduction

In their study of regulation and macroeconomic performance, Dawson and Seater (2013) provide empirical evidence that taxes and regulation altered the time paths of both real output and the relative amounts of the key inputs—physical capital and labor—used to produce a given amount of output over the 1949–2005 period. In other words, their evidence suggests regulation and tax policy affected not only output's path but also how output was produced in the United States. With most of their attention focused on real output and total factor productivity as the dependent variables, however, Dawson and Seater's discussion of the capital and labor inputs is limited and offers no details on the magnitude or direction of the policy effects.

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This paper takes a closer look at the roles played by taxes and regulation in the time paths of capital and labor. The expanded analysis provides a clear picture of how the policy effects differ across the two inputs and the implied effect on the mix of inputs used to produce output in the aggregate economy.

In addition to the more in-depth analysis, recent updates and revisions in the time-series measures of regulation and taxes used by Dawson and Seater allow an extension of the sample period through 2016. New results from the extended sample suggest regulation and taxes play a prominent role in the time paths of both capital and labor—and therefore also the mix of inputs used in production. Moreover, the extension to 2016 provides additional data points that reduce the risk of overfitting in the model used by Dawson and Seater, thus increasing confidence in the estimates provided by the model.

More specifically, the new results indicate that both regulation and taxes have statistically and economically significant effects on the capital and labor inputs, but the regulation effects differ from the tax effects and the respective policy effects differ across the two inputs. In particular, regulation generally decreases the levels of both inputs, and taxes generally increase both inputs. However, the negative effect of regulation dominates the time path of capital, and the positive effect of taxes dominates the movement of labor over time. Together, the combined policy effects decrease the level of capital per worker by more than 50 percent by the end of the 1949–2016 sample period. The prominent role of regulation and taxes in the evolution of capital and labor over time is consistent with Dawson and Seater's results, but their limited discussion of the original results stops short of providing any details about the policy effects.[1]

The paper is organized as follows. The next section briefly describes the data updates and extensions through 2016 that make the current analysis possible. Section 3 briefly describes the empirical methodology used by Dawson and Seater, which is also used here in

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[1] The literature contains many studies on the effects of taxes and specific regulations on labor outcomes and the use of capital in the United States, dating back at least to Rosen (1976) and Brown and Levin (1974), with more recent studies by Mertens and Ravn (2012) and Chen and Lai (2016). The literature on the macro effects of federal regulation is sparse and focused mainly on output or productivity effects, including the Dawson and Seater study and, more recently, Coffey, McLaughlin, and Peretto (2020). This paper fits within the scope of the latter body of literature, but with a focus on the capital and labor inputs in the spirit of Dawson and Seater's original analysis.

the extended analysis. Sections 4 and 5 present and discuss the updated empirical results for labor and capital, respectively, along with the more extensive policy effects implied for the time paths of the two inputs. Section 6 discusses the policy implications for the mix of inputs used in production. The final section concludes.

II. Data

Dawson (2007) and then Dawson and Seater (2013) propose the number of pages in the *Code of Federal Regulations* (hereafter, CFR) as a measure of the extent of federal regulation in the United States. Although the simple page count is an admittedly crude measure of regulation, it provides a consistent measure of US federal regulation over a long time.

Other measures attempt to better capture the restrictiveness of regulation. For example, Coffey, McLaughlin, and Peretto (2020) use text analysis software to count the number of restrictive words in the CFR. While their data have a "quality" dimension that the page-count data lack, their time series is about half as long (starting in 1977).[2] Coffey, McLaughlin, and Peretto do not consider regulation's effect on capital and labor in their study. This paper restricts attention to the page-count measure over the longer sample period for which it is available.

Dawson (2019b) extends the CFR page-count series through 2016 and provides a discussion of the series' behavior during the extended period. Figures 1 and 2 show the extended page-count series and its growth rate, respectively. Figure 2 shows rapid growth in pages of regulation from the early 1960s through the late 1970s, followed by a decline in growth through the 1980s and most of the 1990s. Growth then rises slightly from the late 1990s through the mid-2000s and then begins a very gradual decline around 2005 (the

[2] Figure 1 in Coffey, McLaughlin, and Peretto (2020) shows a close correspondence between the two series over their shorter sample period, suggesting that page-count data for the earlier years probably do a decent job of providing a useful measure of regulation. They get a cumulative effect of regulation (in terms of the reduction in real output) that is about half the size of what Dawson and Seater (2013) found. Half the cumulative effect over roughly half the length of time also suggests about the same effect over the whole period if they could have pushed their measure back to 1949, which also suggests that the alternative measures are measuring about the same thing. See the data appendix in Dawson and Seater for a more detailed account of the page-count measure that discusses issues such as font and organizational changes in the CFR over time.

end of Dawson and Seater's sample period) through 2016. By 2016, growth in pages of regulation is approaching historical lows.[3]

Figure 1
CFR Page-Count Series, 1949-2016

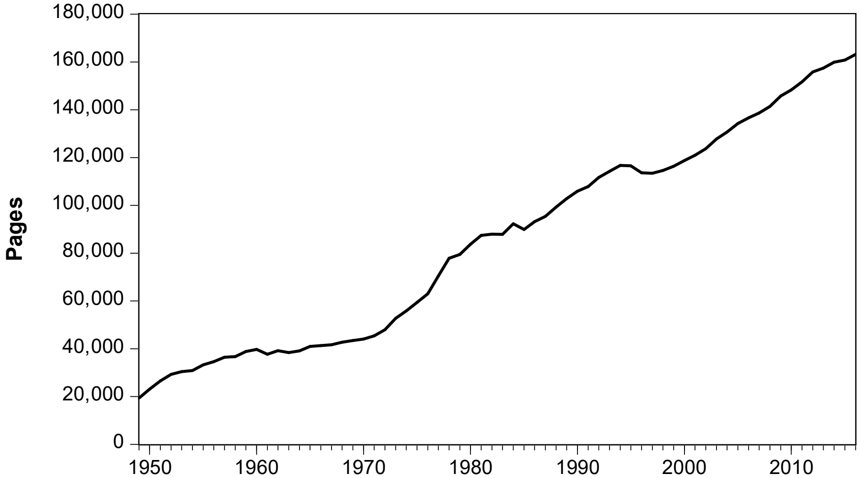
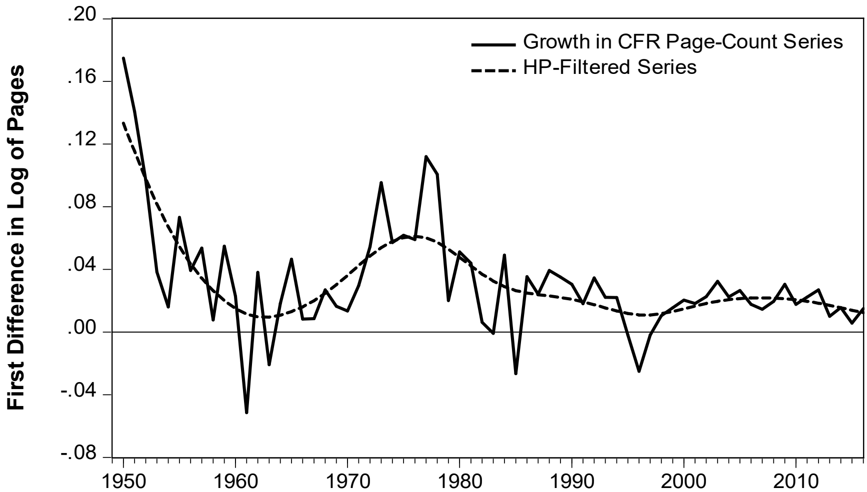


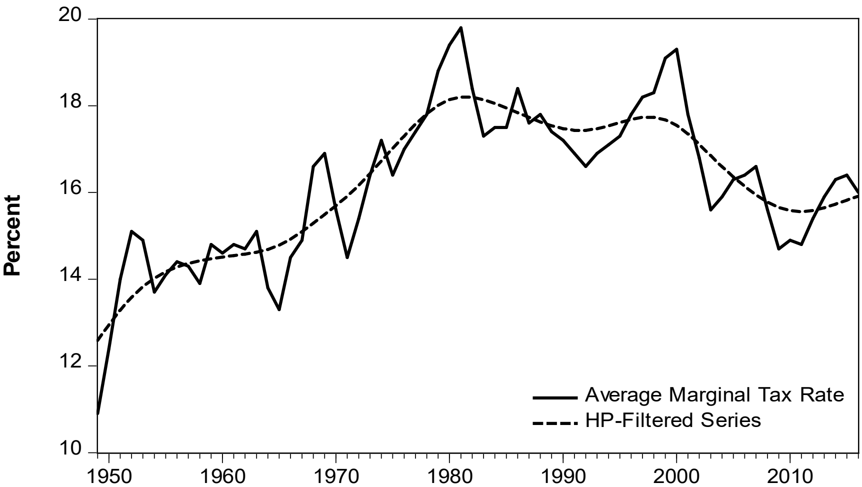
Figure 2
Growth in the CFR Page-Count Series, 1949-2016



[3] Figure 2 and some of the remaining figures in the paper include "smoothed" (HP filtered) series, but all of the analysis that follows uses the raw data only. The smoothed series illustrate general movements in the data, which often are obscured by the high-frequency variation of the raw series.

Dawson and Seater's model also includes taxes as a policy variable. Their measure of taxes is the average marginal effective tax rate, including both the individual income tax and the Social Security tax, from Stephenson (1998), with revisions and updates through 2016 provided by Dawson (2019a). Figure 3 shows the marginal tax rate series over the 1949–2016 period. Taxes rose during much of the period shown in figure 3, peaking around 1980. Then taxes generally declined through the remainder of the period, with the exception of increases in the 1990s and late in the sample following the end of the Great Recession.

Figure 3
Average Marginal Tax Rate, 1949-2016



The dependent variables of interest here are the aggregate factors of production—physical capital (*K*) and labor (*N*). The underlying data are from the Bureau of Labor Statistics.[4] Capital (*K*) is service flows of equipment, structures, inventories, and land, computed as a Tornqvist aggregate of capital stocks using rental prices as weights. Labor (*N*) is hours worked by all persons in the private business sector, computed as a Tornqvist aggregate of hours of all persons using hourly compensation as weights.

Figures 4 and 5 show the growth rates of *K* and *N*. The growth rates of both factors exhibit a good bit of short-term variation. However, the smoothed series indicate some general trends. Capital growth accelerated modestly during the 1960s, followed by a gradual

[4] Downloaded from https://www.bls.gov/mfp/special_requests/mfptablehis.xlsx on February 13, 2019.

decline beginning in the early 1970s through about 1990, and then a noticeable acceleration during the 1990s before declining dramatically during the 2000s. Labor growth exhibits more muted behavior in terms of long-term trends, rising gradually from the early 1960s through the mid-1990s and then falling modestly through about 2010 before a complete recovery by the end of the sample. The Great Recession could be one contributing factor in the declining growth of both factors in the mid- to late-2000s.

Figure 4
Growth in Physical Capital, 1949-2016

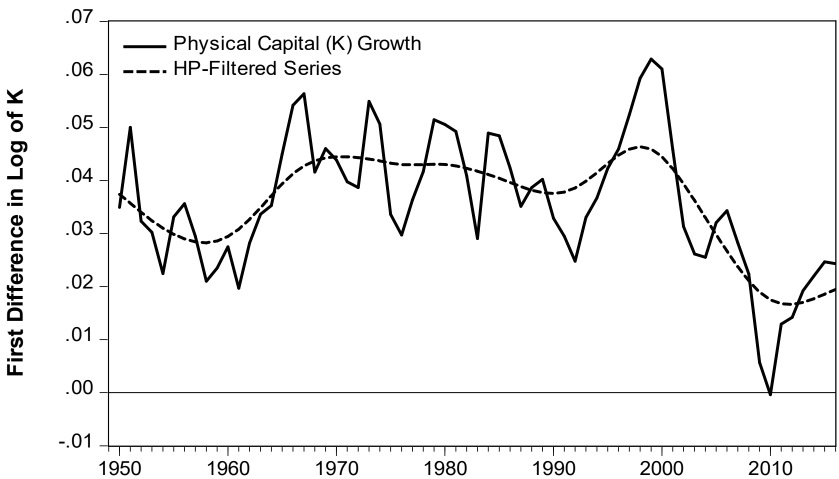
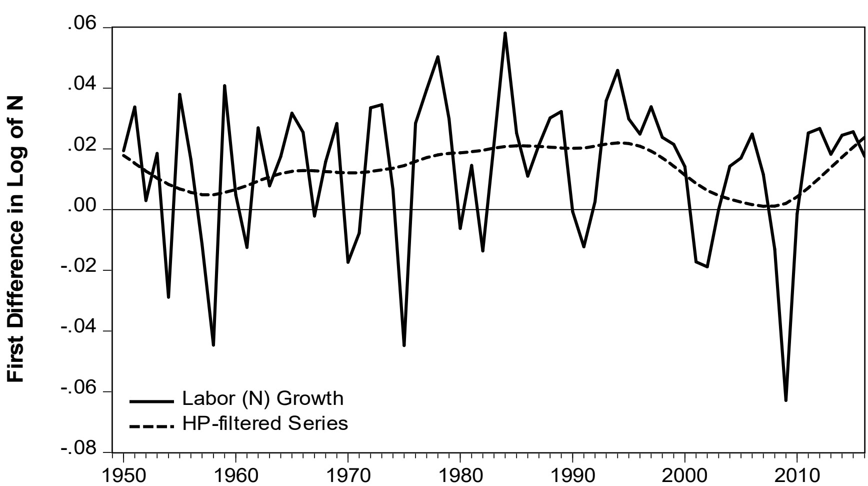


Figure 5
Growth in Labor, 1949-2016



III. Methodology

This section briefly describes the model and empirical procedure, originally proposed by Dawson and Seater (2013), to estimate the effects of regulation and taxes on physical capital (*K*) and labor (*N*).[5] Dawson and Seater derive their regression model from the second-generation endogenous growth model proposed by Peretto (2007). Peretto's model provides a solution for the dependent variable (*x*) of the general form $x = A(\bullet)e^{B(\bullet)t}C(\bullet)$, where $A(\bullet)$ is an intercept term, $B(\bullet)$ is the trend, and $C(\bullet)$ is a transitory or "cycle" effect. The arguments of the functions *A*, *B*, and *C* are subsets of the model parameters and various tax rates. Dawson and Seater adapt this general-form solution for their study of regulation by adding a measure of regulation as an argument in these functions. Peretto's model does not include regulation, so closed-form solutions for $A(\bullet)$, $B(\bullet)$, and $C(\bullet)$ are not available. Instead, Dawson and Seater use quadratic approximations for these functions including current and lagged values of the regulation and tax variables. Dawson and Seater's final estimating equation is

$$x_t = \alpha + \left[\beta + \sum_{j=0}^{J_1^R} \gamma_j^R R_{t-j} + \sum_{j=0}^{J_2^R} \delta_j^R R_{t-j}^2 + \sum_{j=0}^{J_1^T} \gamma_j^T T_{t-j} + \sum_{j=0}^{J_2^T} \delta_j^T T_{t-j}^2\right] t + \sum_{j=0}^{J_3^R} \omega_j^R r_{t-j} + \sum_{j=0}^{J_3^T} \omega_j^T \tau_{t-j} + u_t, \qquad (1)$$

where *x* is the natural log of the relevant factor of production, *K* or *N*; *R* is regulation; *T* is the marginal tax rate; *r* is the natural log of *R*; τ is the natural log of *T*; *a*, β, γ_j, δ_j, and ω_j are constants to be estimated; J_i are lag lengths; and *u* is a log-normally distributed residual. Using the natural log of the dependent variables and the policy variables in some cases (but not others) in this specification is a result of the derivation of (1) in Dawson and Seater (2013).[6]

It is important to emphasize that (1) is a quadratic approximation relating the (current and lagged) regulation and tax variables to the dependent variable and that estimation is carried out using time-series

[5] Dawson and Seater also estimate models for real output and total factor productivity, but attention is restricted here to the capital and labor inputs as dependent variables. See Dawson (2019b) for the latest evidence using real output as the dependent variable and Dawson (2020) for total factor productivity.

[6] See section 4 in Dawson and Seater for details on the derivation of the estimating equation.

methods with a search procedure to determine the appropriate variables and lag lengths to be included (i.e., the "best-fit" model). As such, the reported coefficients from the estimation of (1) represent the various linear and/or quadratic coefficients included in the best-fit time-series model for each dependent variable. The estimated coefficients do not have structural interpretations like those on "variables of interest" in a typical regression model. Instead, to interpret the empirical results, it is useful to recognize that regulation and taxes can have both *trend* and *transitory/cycle* effects on the dependent variable in this model.

More specifically, the policy variables can have two kinds of *trend* effects on the dependent variable in this model: (i) a uniform shift in the trend (a *trend-intercept* effect) and (ii) time-varying breaks in the trend (*trend-linear* and/or *trend-quadratic* effects). For regulation, the trend-intercept effect is calculated as $\beta_R \Sigma \omega_j^R$, where β_R is the trend in regulation. The trend-linear and trend-quadratic effects are determined by the γ_j^R and δ_j^R coefficients. In addition to these trend effects, regulation can also have transitory or *cyclical* effects, as determined by the ω_j^R coefficients. Similar effects on each dependent variable can be obtained for taxes as determined by the analogous coefficients pertaining to taxes along with the underlying trend in taxes, β_T. In other words, for taxes the trend-intercept effect is calculated as $\beta_T \Sigma \omega_j^T$, the trend-linear and trend-quadratic effects are determined by the γ_j^T and δ_j^T coefficients, and the cycle effects are determined by the ω_j^T coefficients.

Since the implied policy effects for each dependent variable are not immediately apparent from individual coefficient estimates, the trend and cycle effects for each policy variable must be calculated using the various coefficient estimates in the functional forms obtained in the best-fit models for capital and labor. These estimated trend and cycle effects are then illustrated graphically in time plots that show the direction and size of the policy effects over the 1949–2016 sample period. For illustrative purposes, the graphical depictions of the various policy effects are therefore more useful in this setting than the actual coefficient estimates reported in the tables. The coefficient estimates reported in the tables are, of course, required for the construction of the graphical effects.

Estimation of (1) is by the dynamic ordinary least squares (DOLS) procedure suggested by Saikkonen (1992) and Stock and Watson (1993) to provide an asymptotically efficient estimator in a cointegrated system. The DOLS procedure augments (1) with

$$\sum_{j=-p}^{q} \mu_j^R \Delta r_{t+j} + \sum_{j=-p}^{q} \mu_j^T \Delta \tau_{t+j} \qquad (2)$$

to eliminate the feedback in the cointegrating system. Standard OLS estimates of the coefficients from the augmented regression are consistent, but the usual *t*- and *F*-statistics must be rescaled using an estimate of the long-run variance of the DOLS residuals. See Hamilton (1994, pp. 608–12) for a description of this nonparametric correction for serial correlation. The μ_j coefficients on the leads and lags in (2) are of no practical interest and thus are not reported. The lag lengths J_i on the regulation and tax variables in (1) and the appropriate number of lags p and leads q in (2) are chosen using a search procedure to find the lag structure that minimizes the Schwarz-Bayes criterion.[7]

To ensure that the DOLS procedure for estimating a cointegrating system is appropriate in this setting, the variables in (1) are pretested for stationarity. The DF-GLS (Elliott, Rothenberg, and Stock 1996) test cannot reject the unit-root null hypothesis in any of the model variables at the 5 percent level.[8] However, conventional unit-root tests often fail to reject the unit-root null when there is a break in the trend function under the stationary alternative hypothesis. Thus, we consider the unit-root test proposed by Zivot and Andrews (1992), which assumes a break in both intercept and trend at an unknown, endogenously determined time. The Zivot–Andrews test also fails to reject the unit-root null for all of the variables. These results suggest the model variables are individually nonstationary and the DOLS procedure for estimating a cointegrating system is appropriate.[9] Finally, to examine the

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[7] See Dawson and Seater (2013) for details on the search procedure. The search procedure is designed to arrive at the time-series model that best fits the underlying data—that is, which policy variables to include and how many lags of each included variable. If the data dictate that the best fit is achieved without a given policy variable (or a given lag), then it will not appear in the reported "best-fit" model. In this respect, the search procedure is used strictly in a "time series" sense to determine the appropriate lag lengths of the policy variables in (1) and the leads and lags in (2). It is not used in an attempt to "fish out" a certain result based on some prior expectation.

[8] The DF-GLS tests include an intercept and trend. The test results discussed here are not reported, but are available from the author upon request.

[9] Testing directly for cointegration is also possible, but the available tests have low power or are inconsistent with the underlying theory. Thus, Dawson and Seater (2013) proceed with the assumption of cointegrated variables. See additional details in Dawson and Seater.

sensitivity of the policy variables (*R* and *T*) to the dependent variables (*K* and *N*), Granger-causality tests are performed. The results indicate no causality running from the dependent variables to either of the policy variables, a finding that is consistent with econometric exogeneity of the policy variables.[10]

Before turning to the results from the DOLS estimation of (1) in the next section, it is worthwhile to acknowledge that estimating models with a large number of parameters using a relatively small number of observations runs a risk of overfitting the model. Dawson and Seater's search procedure includes the potential for estimating up to forty-six parameters. Fortunately, the best-fit models reported in their study include far fewer parameters. For example, their best-fit specifications for *K* and *N* over the 1949–2005 period include twelve and thirteen parameters each, respectively. The best-fit specification for labor reported below for the 1949–2016 period includes only eleven parameters, although the best-fit specification for capital includes twenty-three parameters. However, extending the sample to 2016, which provides eleven more data points than Dawson and Seater's original sample, further reduces the risk of overfitting. This is another important contribution of the updated analysis.

IV. Empirical Results: Labor

The best-fit model estimate for labor (*N*) over the 1949–2016 period is reported in table 1. The left panel shows estimates pertaining to the regulation coefficients for labor. For the regulation coefficients, the model *structure* reported here for 1949–2016 is identical (in terms of variables included and lag lengths) to the best-fit model for labor reported by Dawson and Seater (2013) for the shorter 1949–2005 period. However, the coefficient estimates have different *magnitudes* than those reported in Dawson and Seater, thus implying different estimates of regulation's effect on *N*.[11]

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[10] It is possible, of course, that some other factor(s) might be causing both changes in taxes/regulation and capital/labor. The discussion here is limited to the interaction between the regulation and tax policy variables and the capital and labor inputs in an endogenous growth setting as originally framed in Dawson and Seater (2013).

[11] To be clear, the models reported here differ from those reported in Dawson and Seater (2013) only in terms of the sample period and resulting best-fit model selection. Therefore, any differences in estimated parameters and/or model structure are explained by the extended sample period alone. To be clear, if the model were re-estimated over the shorter 1949–2005 period used in Dawson and

Table 1. Model estimates for labor (*N*), 1949–2016

$$\ln(N_t) = \alpha + \left[\beta + \sum_{j=0}^{J_1^R} \gamma_j^R R_{t-j} + \sum_{j=0}^{J_2^R} \delta_j^R R_{t-j}^2 + \sum_{j=0}^{J_1^T} \gamma_j^T T_{t-j} + \sum_{j=0}^{J_2^T} \delta_j^T T_{t-j}^2\right] t + \sum_{j=0}^{J_3^R} \omega_j^R r_{t-j} + \sum_{j=0}^{J_3^T} \omega_j^T \tau_{t-j} + u_t$$

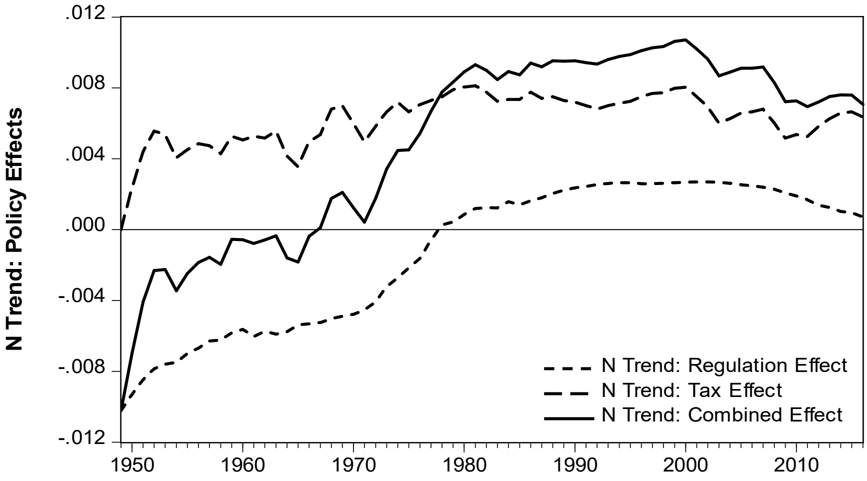
Regulation Parameters		*Tax and Other Model Parameters*	
γ_0^R	2.97E-07 (13.310)	γ_0^T	0.0036 (3.352)
δ_0^R	−1.21E-12 (−12.597)	δ_0^T	−8.75E-05 (−2.795)
ω_0^R	−0.201 (−1.964)	$\Sigma\gamma_j^T$ {*F* test: $\Sigma\gamma_j^T = 0$} [p-value]	0.0036 {NA} [NA]
ω_0^R	−0.147 (−1.488)	$\Sigma\delta_j^T$ {*F* test: $\Sigma\delta_j^T = 0$} [p-value]	−8.75E-05 {NA} [NA]
$\beta_R\Sigma\omega_j^R$	−0.0102	α	11.599 (30.331)
$\Sigma\gamma_j^R$ {*F* test: $\Sigma\gamma_j^R = 0$} [p-value]	2.97E-07 {NA} [NA]	β	−0.031 (−3.312)
$\Sigma\delta_j^R$ {*F* test: $\Sigma\delta_j^R = 0$} [p-value]	−1.21E-12 {NA} [NA]	*p*, *q*	2, 1
$\Sigma\omega_j^R$ {*F* test: $\Sigma\omega_j^R = 0$} [p-value]	−0.348 {86.551} [0.000]		

Notes: Estimation by DOLS includes p lags and q leads of Δrt and Δτt whose coefficient estimates are not reported. Only parameter estimates included in the best-fit model are reported. Numbers in parentheses (.) are t-statistics corrected for serial correlation using the nonparametric procedure described in Hamilton (1994, pp. 608–12) and may be compared to standard t tables. Numbers in braces {.} are F-statistics corrected in a similar manner and may be compared to standard F tables. Nonparametric correction may result in unusually large t and F values. Numbers in brackets [.] are p-values. Numbers do not always add because of rounding. NA ≡ not applicable (when there is only one nonzero parameter, making the sum trivial and calculation of F tests superfluous). The value of βR is 0.0294 and the value of βT is 0.002863.
Source: Author's calculations.

Seater, the results would be identical to what they report (since the same data, model, and estimation procedure is used here).

Two ω_j^R coefficients are reported for N in table 1, which sum to −0.348. The estimate of regulation's trend, obtained from estimating $r_t = \alpha_R + \beta_R t + \nu_t$, is $\beta_R = 0.0294$, which provides a trend-intercept effect of $\beta_R \Sigma \omega_j^R = -0.0102$. This estimate suggests a uniform reduction of one percentage point in labor's trend due to regulation, but this effect is less than half of Dawson and Seater's estimate of −0.0220. In addition, the γ_0^R and δ_0^R coefficients reported in table 1 suggest regulation has time-varying (trend-linear and trend-quadratic) effects on labor's trend. Taking these effects into account, regulation's total effect on labor's trend is shown in figure 6.

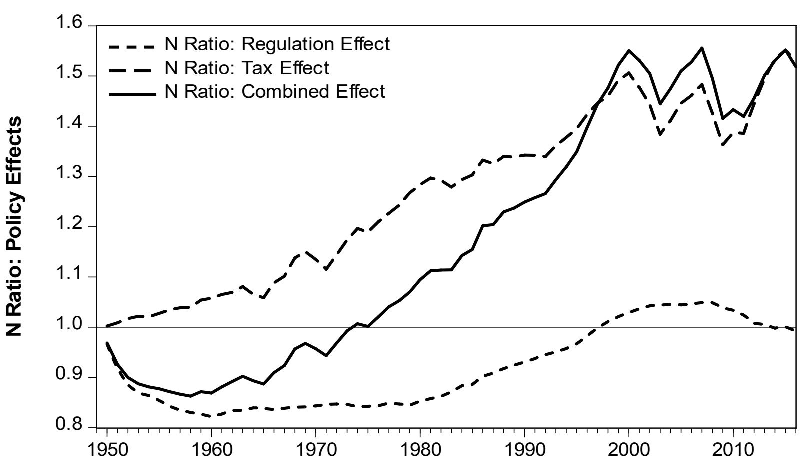
Figure 6
Effects of Regulation and Tax Policy on Labor's (N) Trend



The effect is initially negative, but increasing regulation raises labor's trend (that is, makes the effect on labor's trend less negative), and the effect becomes positive beginning in the late 1980s. In particular, rapid growth in regulation during the 1970s sharply increases labor's trend during this period. Once regulation's effect on labor's trend turns positive, it levels off with the moderation in regulatory growth beginning in the early 1980s. Dawson and Seater did not report the effect on N analogous to that shown in figure 6, as most of their attention was on the output and total factor productivity results with no discussion of specific policy effects on the N and K inputs. The same lack of comparable results from Dawson and Seater applies for all remaining figures throughout this paper. The previously unseen policy effects illustrated in these figures are this paper's main contribution.

The trend effect shown in figure 6 is not the total effect of regulation on labor. The significantly negative ω_0^R and ω_1^R coefficients indicate that regulation has a substantial cycle effect on labor. The combined trend and cyclical effects of regulation can be obtained by using the parameter estimates and regulation data to construct a counterfactual series showing the level of *N* had regulation remained at its 1949 level. Figure 7 shows the ratio of actual *N* to counterfactual *N*.[12] The time pattern is irregular. The ratio is initially negative, hovering in the 80–85 percent range through the 1960s and 1970s before rising and eventually becoming slightly positive in the late 1990s. By the end of the sample, labor is 99 percent of its counterfactual value, suggesting that the cumulative effect of regulation added since 1949 had little to no effect on the level of labor by 2016.

Figure 7
Ratio of Actual to Counterfactual Labor (N)
(assuming policy held constant at 1949 levels)



Taxes may also play a role in explaining labor's time path. The right panel of table 1 reports the tax coefficients in the best-fit model for *N*. For the tax coefficients, the model structure is simpler than the model reported by Dawson and Seater, thus implying different estimates of the tax effects in the extended sample period. The

12 See Dawson and Seater (2013), in particular their footnote 19, for details on the construction of the counterfactual series. Graphing the actual-to-counterfactual *ratio* (as opposed to graphing the two series separately) simplifies the comparison of different policy effects in the same graph (i.e., requires fewer curves) and more clearly illustrates differences in the relative growth rates of the actual and counterfactual series during periods of regulatory and/or tax changes.

coefficients reported here are used to estimate the tax effects just as the regulation effects were estimated above. There are no statistically significant ω_j^T coefficients in the best-fit model for labor, so there is no trend-intercept effect for taxes. Dawson and Seater also report a zero trend-intercept effect for taxes. However, the γ_0^T and δ_0^T coefficients do suggest trend-linear and trend-quadratic effects from taxes. Figure 6 shows the total effect of taxes on labor's trend alongside the regulation effect discussed above. The effect is uniformly positive, peaking at 0.0081—or about eight-tenths of a percentage point—in 1980 before declining somewhat afterward. In particular, it is noteworthy that the upward trend in the marginal tax rate (see figure 3) from the mid-1960s through about 1980 roughly doubles the effect on labor's trend from a value of 0.0036 in 1965 to 0.0081 in 1980. Interestingly, the tax effect declines with tax cuts in the 1980s and then peaks again at 0.008 in 2000 following tax increases during the 1990s.

Figure 7 plots the ratio of actual *N* to counterfactual *N* obtained by holding the marginal tax rate constant at its 1949 level. Again, the tax effect is uniformly positive. Also apparent is the increase in the ratio from a value of 1.06 in 1965 to a peak of 1.55 in 2000 during the period of tax increases mentioned in the previous paragraph. The ratio reaches a value of 1.52 at the end of the sample in 2016, suggesting the actual level of *N* is 52 percent higher at the end of the sample period than if taxes had remained constant at their 1949 level.

Figures 6 and 7 also include the combined effects of both regulation and taxes on labor's trend and actual-to-counterfactual ratio, respectively. The patterns over time are similar to those discussed previously, with increases in regulation and the marginal tax rate from the mid-1960s through the 1970s sharply increasing labor's trend and the ratio of actual to counterfactual labor during this period. By the end of the sample, however, it is apparent in figure 7 that the cumulative effect of tax changes outweighs that of regulation on the ratio of actual to counterfactual labor.

V. Empirical Results: Physical Capital

Table 2 reports the best-fit model estimate for physical capital (*K*). A quick comparison with the results for *N* in table 1 reveals a more complex model with a deeper lag structure for *K* than for *N*, particularly for the regulation coefficients (in the left panel of both tables).

Table 2. Model estimates for physical capital (*K*), 1949–2016

$$\ln(K_t) = \alpha + \left[\beta + \sum_{j=0}^{J_1^R} \gamma_j^R R_{t-j} + \sum_{j=0}^{J_2^R} \delta_j^R R_{t-j}^2 + \sum_{j=0}^{J_1^T} \gamma_j^T T_{t-j} + \sum_{j=0}^{J_2^T} \delta_j^T T_{t-j}^2\right] t + \sum_{j=0}^{J_3^R} \omega_j^R r_{t-j} + \sum_{j=0}^{J_3^T} \omega_j^T \tau_{t-j} + u_t$$

Regulation Parameters		*Tax and Other Model Parameters*	
γ_0^R	−5.11E-07 (−3.922)	ω_0^T	−0.241 (−4.511)
γ_1^R	−1.66E-08 (−0.094)	ω_1^T	0.388 (7.756)
γ_2^R	2.82E-07 (1.545)	$\beta_T\Sigma\omega_j^T$	0.0004
γ_3^R	4.89E-07 (3.561)	$\Sigma\omega_j^T$ {*F* test: $\Sigma\omega_j^T = 0$} [p-value]	0.147 {3.928} [0.058]
δ_0^R	1.46E-12 (2.912)	α	8.209 (36.417)
δ_1^R	6.33E-15 (0.009)	β	0.037 (22.771)
δ_2^R	−9.09E-13 (−1.208)	*p*, *q*	5, 4
δ_3^R	−1.84E-12 (−3.311)		
ω_0^R	0.644 (5.285)		
ω_0^R	−0.916 (−8.249)		
$\beta_R\Sigma\omega_j^R$	−0.0080		
$\Sigma\gamma_j^R$ {*F* test: $\Sigma\gamma_j^R = 0$} [p-value]	2.44E-07 {173.480} [0.000]		
$\Sigma\delta_j^R$ {*F* test: $\Sigma\delta_j^R = 0$} [p-value]	−1.28E-12 {280.978} [0.000]		
$\Sigma\omega_j^R$ {*F* test: $\Sigma\omega_j^R = 0$} [p-value]	−0.272 {73.604} [0.000]		

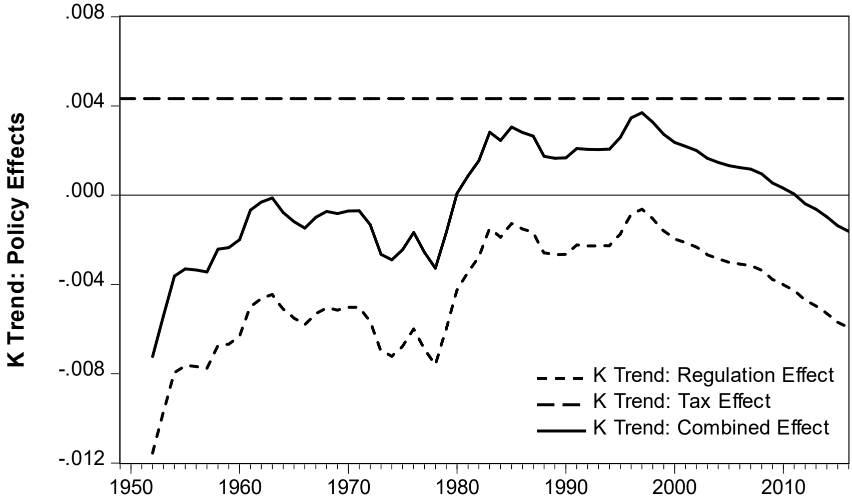
Notes: Estimation by DOLS includes p lags and q leads of Δr_t and $\Delta \tau_t$ whose coefficient estimates are not reported. Only parameter estimates included in the best-fit model are reported. Numbers in parentheses (.) are t-statistics corrected for serial correlation using the nonparametric procedure described in Hamilton (1994, pp. 608–12) and may be compared to standard t tables. Numbers in braces {.} are F-statistics corrected in a similar manner and may be compared to standard F tables. Nonparametric correction may result in unusually large t and F values. Numbers in brackets [.] are p-values. Numbers do not always add because of rounding. NA ≡ not applicable (when there is only one nonzero parameter, making the sum trivial and calculation of F tests superfluous). The value of β_R is 0.0294 and the value of β_T is 0.002863.
Source: Author's calculations.

The model structure for the regulation coefficients in table 2 is also more complex in terms of variables included and lag structure than the best-fit model for capital reported by Dawson and Seater. Furthermore, the coefficients reported here differ in both sign and magnitude from those reported by Dawson and Seater, thus implying substantially different effects from regulation in the extended sample period considered here.

Two ω_j^R coefficients are statistically significant for K in table 2, which sum to −0.272. Along with the previously reported estimate of regulation's trend ($\beta_R = 0.0294$), this suggests a trend-intercept effect of $\beta_R \Sigma \omega_j^R = -0.008$, indicating a uniform reduction of eight-tenths of a percentage point in capital's trend due to regulation. This estimate is considerably smaller than the estimated trend-intercept effect of −0.014 reported by Dawson and Seater. In addition, the γ_j^R and δ_j^R coefficients reported in table 2 suggest complex trend-linear and trend-quadratic effects.

Figure 8 shows regulation's total effect on capital's trend. The effect is always negative, but varies over time. Increases in regulation increase capital's trend (that is, the effect becomes less negative) through the 1950s and early 1960s. But rapid growth in regulation starting in the mid-1960s (see figure 2) has an increasingly negative effect on capital's trend through the late 1970s. Then slowing growth in regulation in the 1980s and into the 1990s sharply reduces the negative effect on capital's trend during this period. The effect on capital's trend turns increasingly negative again as regulatory growth begins to increase once again beginning in the mid- to late-1990s.

Figure 8
Effects of Regulation and Tax Policy on Physical Capital's (K) Trend



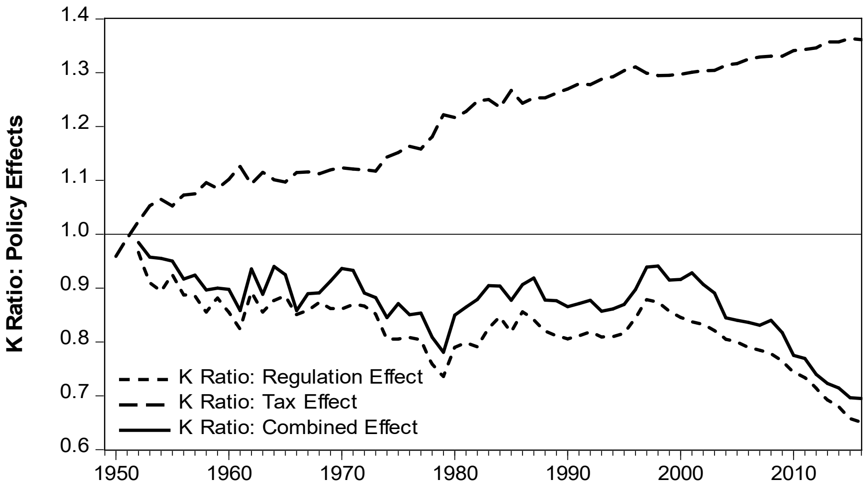
The presence of statistically significant ω_j^R coefficients in the model suggests regulation also has cyclical effects on capital. The combined trend and cycle effects of regulation on capital's time path are obtained by constructing the hypothetical series for K assuming regulation held constant at its 1949 level. Figure 9 shows the ratio of actual K to the counterfactual K series. The ratio is always less than one, indicating that regulation added since 1949 reduced the level of capital throughout the sample period. However, the time pattern is irregular. In particular, rapid regulatory growth from the mid-1960s through the 1970s sharply reduces capital to about 75 percent of its counterfactual by the late 1970s.Then, slowing growth in regulation through the 1980s and 1990s raises the ratio to around 90 percent by the late 1990s. The ratio begins another sharp decline in the late 1990s, as regulatory growth picks up once again around this time. By 2016, the overall decline in capital is large, down to 65 percent of its counterfactual level, reflecting the reduction in capital's trend and accumulation of cycle effects over the sixty-eight-year sample period.

Table 2 also reports the tax coefficients in the best-fit model for K (see the right panel). There are two significant ω_j^T coefficients, which sum to 0.147. However, the estimate of the trend in the marginal tax rate series $\tau = \log(T)$, obtained from estimating $\tau_t = \alpha_T + \beta_T t + w_t$, is $\beta_T = 0.002863$, suggesting a small trend-intercept effect of $\beta_T \Sigma\omega_j^T = 0.0004$. This result suggests that taxes are associated with a uniform increase of only 0.04 percentage points in capital's trend.

Again, this is smaller than Dawson and Seater's estimated trend-intercept effect of 0.0030. In addition, there are no significant γ_0^T and δ_0^T coefficients in the model for capital, which implies no time-varying trend-linear and trend-quadratic effects on capital's trend from taxes. Thus, the uniform tax effect on capital's trend in figure 8 is shown by a constant (horizontal) trend-intercept effect.

The two significant ω_j^T coefficients, however, do suggest that taxes have substantial cycle effects on capital. Once again, the combined trend and cycle effects are shown in figure 9 by the ratio of actual *K* to counterfactual *K* assuming the marginal tax rate held constant at its 1949 level. Except for the first couple of years, the ratio is uniformly greater than one and steadily rising over time, with actual *K* about 36 percent greater than its counterfactual by the end of the sample period. Given the absence of any significant trend effects from taxes, this positive tax effect primarily reflects accumulated cycle effects over the sample period.

Figure 9
Ratio of Actual to Counterfactual Capital (K)
(assuming policy held constant at 1949 levels)



Figures 8 and 9 also include the combined effects of both regulation and taxes on capital's trend and actual-to-counterfactual ratio, respectively. The small tax effect on capital's trend, discussed above, is enough in figure 8 to turn the combined effect positive beginning in 1980 through most of the remainder of the sample period. More interesting, however, is the combined policy effect on the ratio of actual to counterfactual *K* (assuming both regulation and capital held constant at their 1949 levels). The ratio displays the same general time pattern as that previously discussed for regulation alone, with actual K only 69 percent of its counterfactual by the end of the sample period. This negative effect for regulation and taxes combined suggests the negative effect of regulation dominates the positive effect of taxes on capital's time path.

Taken together, the results for labor and capital reported in tables 1 and 2 suggest an interesting and complex story about the effects of regulation and tax policy on these key factors of production. Although regulation effects are generally negative and tax effects generally positive for both factors, the results for combined policy effects reveal that tax effects dominate for labor's time path while regulation dominates for capital. The results also indicate that rapid increases in both regulation and tax rates from the mid-1960s through the 1970s have distinct effects on the evolution of both factors of production during this period—again with tax effects dominating for labor (in figure 7) and regulation dominating for capital (in figure 9). Subsequently, declining tax rates and slower regulatory growth in the 1980s also appear to reverse the course of these effects.

Dawson and Seater (2013) and more recently Dawson (2020) suggest that changes in taxes and regulation also coincide with the famous "productivity slowdown" of the 1970s. Slowing factor productivity could also be part of the bigger picture of how taxes and regulation affect the mix of inputs used to produce output in the US economy. For example, policy-induced changes in factor productivity may necessitate changes in the mix of inputs used to produce a given amount of output. The next section provides a closer look at what the models for labor and capital in tables 1 and 2 suggest for the mix of inputs used in production.

VI. Policy Effects and the Mix of Inputs

The level of capital per worker—or capital-labor ratio (K/N)—provides a representation of the mix of these key inputs used to produce output. Figure 10 shows the time path of the actual capital-labor ratio in the United States over the period 1949–2016. Capital per worker rises gradually over the sample period, reaching a value of 0.59 in 2016. The model estimates for labor and capital reported in tables 1 and 2, meanwhile, are used to obtain the counterfactual series for K/N assuming regulation and taxes held constant at 1949 levels.

Figure 10 also shows these counterfactual series—for regulation and taxes individually as well as the two policy effects combined. The counterfactual series for taxes and regulation individually both indicate hypothetical values of K/N that are above the actual K/N ratio for most of the period shown, which suggests both regulation and taxes have negative effects on the level of capital per worker used in production. The counterfactual series for regulation generally trends above that for taxes, indicating that the effect of regulation outweighs that of taxes on the input mix. The counterfactual series for the combined tax and regulation effects indicates a value of 1.29 for K/N by the end of the sample period, had tax rates and regulation remained constant at their 1949 levels—a hypothetical value that is more than double the actual K/N ratio for 2016. This estimate reflects the effects of tax and regulation policy on the trends of the labor and capital inputs along with accumulated cycle effects over the sample period.

Figure 10
Capital per Worker (K/N): Actual vs. Counterfactual
(assuming policy held constant at 1949 levels)

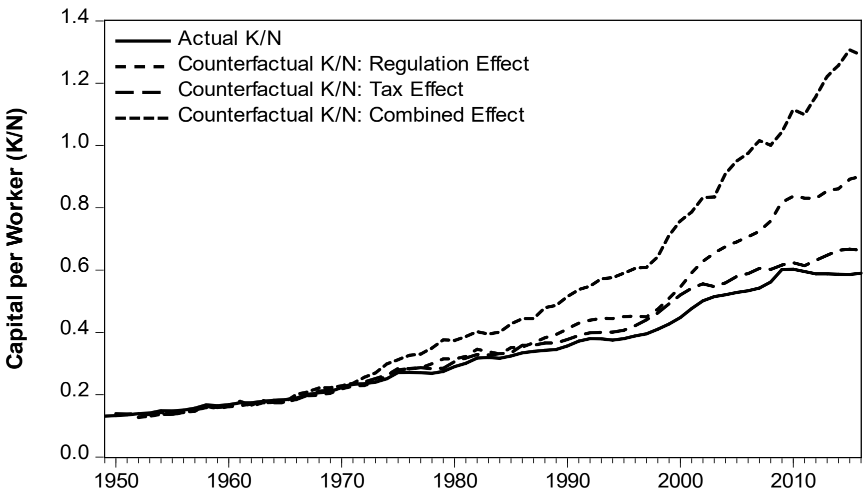


Figure 11 provides a different way to look at these policy effects on the mix of inputs. It shows the ratios of actual K/N to the counterfactual K/N series shown in figure 10. All of the actual-to-counterfactual ratios fall below one by the early 1970s and remain below one for the duration of the sample period. These estimates reflect the negative effects of taxes and regulation on the level of capital per worker from Figure 10. Again, the negative effect of regulation is larger than that for taxes.

Figure 11
Ratio of Actual to Counterfactual Capital per Worker (K/N)
(assuming policy held constant at 1949 levels)

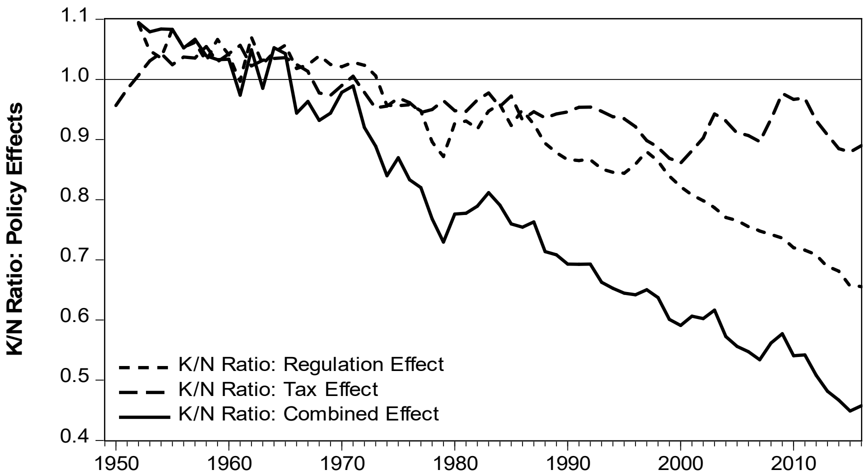


Figure 11 also shows the actual-counterfactual ratio for the combined effects of taxes and regulation, which depicts actual K/N falling to less than half—46 percent to be exact—of its counterfactual by 2016 (as previously discussed in figure 10). Figure 11 shows much more clearly, however, the sharp decline in the actual-counterfactual ratio from a value of 1.06 in 1965 to 0.73 in 1979 during the period of rising tax rates and rapid growth in regulation. Following a brief recovery in the early 1980s, the ratio resumes a steady decline through the remainder of the period shown, due primarily to the increasingly negative effect of regulation on the input mix.

The precipitous decline in the actual-counterfactual ratio beginning after the brief recovery in the early 1980s through the end of the sample—due largely to the increasingly negative effect of regulation during this period—is interesting in that it occurs during a time of relatively slow regulatory growth. That is, even though regulatory growth accelerates somewhat beginning in the late 1990s through the late 2000s, the growth rate of regulation is noticeably slower than during the mid-1960s to late 1980s. It therefore appears that regulation can alter the input mix without the excessive growth in regulation witnessed earlier in the sample.

The recent study by Coffey, McLaughlin, and Peretto (2020) offers a possible explanation that can be applied to the new association between regulation and the input mix late in the sample period. They argue that the effect of a growing regulatory regime is *cumulative* in nature—that is, "the effect of government intervention on economic growth is not simply the sum of static costs associated with individual interventions" (Coffey, McLaughlin, and Peretto 2000, p. 3). Mandel and Carew (2013) originally framed this idea in the context of regulation: "For each new regulation added to the existing pile, there is a greater possibility for interaction, for inefficient company resource allocation, and for reduced ability to invest in innovation. The negative effect on US industry of regulatory accumulation actually compounds on itself for every additional regulation added to the pile" (Mandel and Carew 2013, p. 4). If regulation has such a cumulative effect, then years of regulatory build-up may eventually take a toll—such as the continued deceleration in capital per worker—even as current regulatory growth remains slow by historical standards.

Taken together, the behavior of the K/N ratio suggested in figures 10 and 11 implies statistically and economically significant effects of taxes and regulation on the mix of inputs used to produce output in the US economy. This result reflects the combined positive effect of policy on labor's time path (primarily from taxes, as shown in figure 7) and the negative effect of policy on capital accumulation (primarily from regulation, as shown in figure 9).

VII. Conclusion

This paper provides empirical estimates of the role of regulation and taxes on the time paths of the key factors of production—physical capital and labor—in the United States over the period 1949–2016. The analysis uses a time-series model along with recently updated data on the extent of federal regulation and marginal tax rates. The updated analysis and expanded discussion of policy effects provide the first in-depth look at the effects of regulation and tax policy on the key capital and labor inputs in the aggregate economy.

The results suggest statistically and economically significant effects of both regulation and taxes on the growth of both factors of production. However, the effects of regulation differ from those of taxes and the effects differ across the two inputs. More specifically, tax changes have generally increased the levels of both factors, while changes in regulation have generally decreased both factors. But the positive effect of taxes dominates the time path for labor and the negative effect of regulation dominates the time path for capital. The combined policy effects on capital and labor substantially alter the mix of inputs used to produce output in the US economy—decreasing the level of capital per worker by more than 50 percent by the end of the sample period.

The results also indicate discernible effects on both factors during the period of rapid growth in regulation and increasing tax rates from the mid-1960s through the 1970s, with slowing regulatory growth and lower tax rates beginning in the early 1980s reversing these effects somewhat. By the end of the sample period, however, the increasingly negative effect of accumulated regulation appears to be the predominant policy factor affecting the input mix.

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