Measuring Capital-Labor Substitution: The Importance of Method Choices and Publication Bias

Sebastian Gechert,[1] Tomas Havranek,[2] Zuzana Irsova,[2] and Dominika Kolcunova[2,3]

[1]Macroeconomic Policy Institute, Düsseldorf; [2]Charles University, Prague; [3]Czech National Bank

IMK Macroeconomic Policy Institute

Abstract

We show that the large elasticity of substitution between capital and labor estimated in the literature on average, 0.9, can be explained by three issues: publication bias, use of cross-country variation, and omission of the first-order condition for capital. **The mean elasticity conditional on the absence of these issues is 0.3**. To obtain this result, we collect 3,186 estimates of the elasticity reported in 121 studies, codify 71 variables that reflect the context in which researchers produce their estimates, and address model uncertainty by Bayesian and frequentist model averaging.

We employ nonlinear techniques to correct for publication bias, which is responsible for at least half of the overall reduction in the mean elasticity from 0.9 to 0.3. Our findings also suggest that a failure to normalize the production function leads to a substantial upward bias in the estimated elasticity. The weight of evidence accumulated in the **empirical literature emphatically rejects the Cobb-Douglas specification.**

Introduction

Among other things, the size of the elasticity has practical consequences for monetary policy, as Figure 1 illustrates. In the SIGMA model used by the Federal Reserve Board, the **effectiveness of interest rate changes in steering inflation doubles when one assumes the elasticity to equal 0.9 instead of 0.5**, yielding wildly different policy implications. We choose the SIGMA model for the illustration because, as one of very few models employed by central banks, it actually allows for different values of the elasticity of substitution. Almost all models use the convenient simplification of the Cobb-Douglas production function, which implicitly assumes that the elasticity equals one. If the true elasticity is smaller, these models overstate the strength of monetary policy and should imply a more aggressive campaign of interest rate cuts in response to a recession.

Figure 1. The elasticity of substitution matters for monetary policy

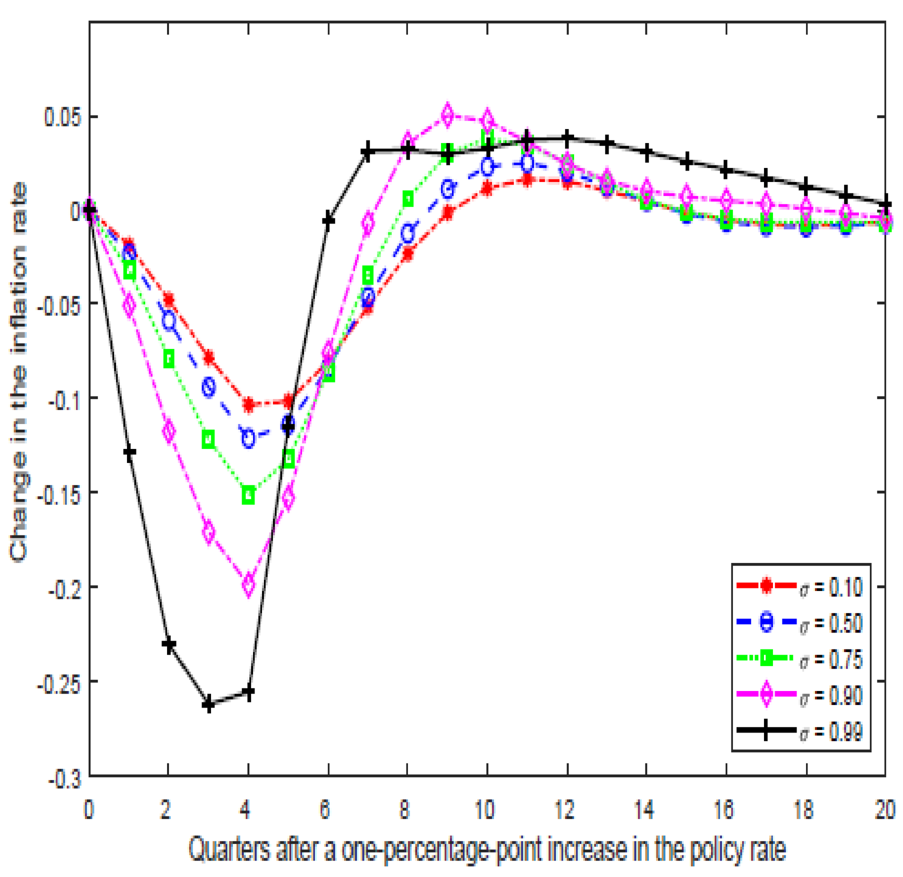
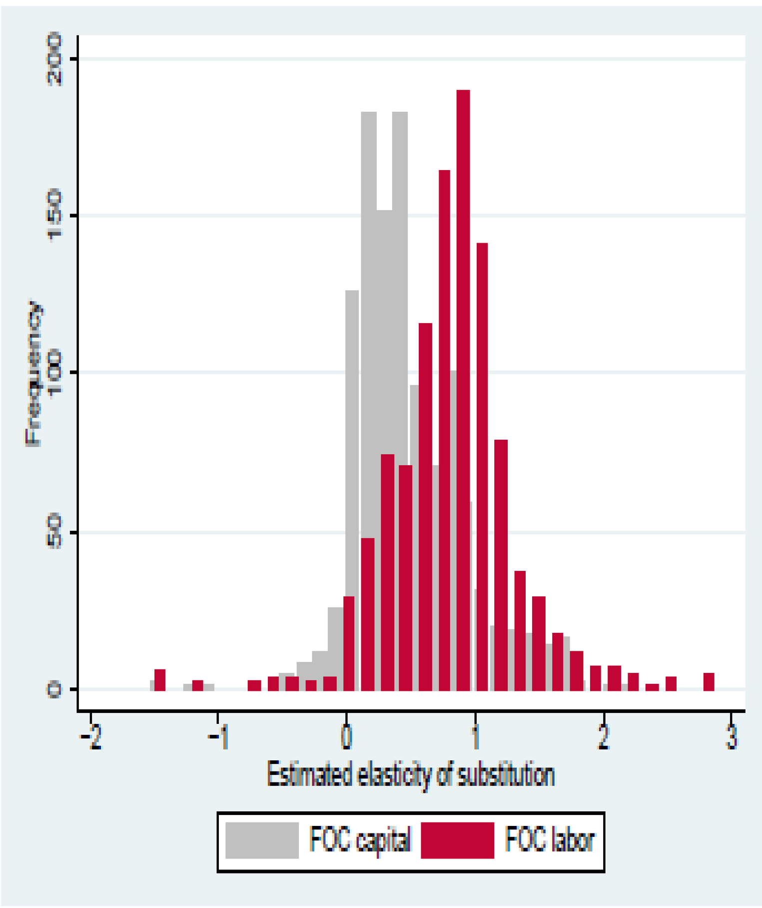


Figure 2. Labor estimates are larger than capital estimates



Data

We use Google Scholar to search for studies estimating the elasticity; we terminate the search on August 1, 2018. To be included in our dataset a study must satisfy two criteria. First, the study must be published. This criterion is mostly due to feasibility since even after restricting our attention to published studies the dataset involves a manual collection of hundreds of thousands of data points. Second, the study must report standard errors or other statistics from which precision can be computed. If the elasticity is not reported directly, but can be derived from the results, we use the delta method to approximate the standard error. In total **we collect 3,186 estimates of the elasticity from 121 studies**, together with 71 variables that reflect the context in which the estimates are produced. One of the striking facts is that estimates derived from the FOC for capital tend to be smaller than those derived from the FOC for labor (Figure 2). The overall mean is 0.9.

Publication Bias

Negative estimates of the elasticity are unintuitive; insignificant estimates are uninteresting. Both may get underreported in the literature, which would bias the mean upwards. Because almost all estimates of excess sensitivity are produced by methods that imply the ratio of the estimate to its standard error to have a t-distribution, **estimates and standard errors should not be correlated**. The strong correlation, shown in Table 1, indicates bias (e.g., large standard errors are compensated by specification searching that produces a large point estimate). The results are corroborated by recently developer non-linear tests that relax the assumption that publication bias is a linear function of the standard error.

Table 1. After correction for publication bias, the mean elasticity decreases from 0.9 to about 0.5

	OLS	FE	BE	Precision	Study	IV
SE (publication bias)	0.881^{***}	0.656^{***}	1.111^{***}	1.025^{***}	0.888^{***}	2.186^{***}
	(0.086)	(0.201)	(0.190)	(0.115)	(0.094)	(0.413)
	[0.49; 1.21]	–	–	[0.59; 1.40]	[0.62; 1.22]	[1.20; 3.68]
Constant (mean beyond bias)	0.492^{***}	0.529^{***}	0.499^{***}	0.468^{***}	0.544^{***}	0.279^{***}
	(0.028)	(0.033)	(0.048)	(0.025)	(0.039)	(0.070)
	[0.38; 0.61]	–	–	[0.36; 0.61]	[0.44; 0.64]	[0.04; 0.47]
Studies	121	121	121	121	121	121
Observations	3,186	3,186	3,186	3,186	3,186	3,186

	Bom & Rachinger (2019)	Furukawa (2019)	Andrews & Kasy (2019)	Ioaninidis et al. (2017)
Mean beyond bias	0.52	0.55	0.43	0.50
	(0.09)	(0.21)	(0.02)	(0.06)

Results

We regress the estimated elasticities on the 71 variables representing estimation context. To address model uncertainty we use Bayesian model averaging. To address collinearity we use the dilution prior. Three variables appear the most important (Figure 3, Table 2): **standard error** (corroborating publication bias), **aggregation** (country-level data vs. industry- and firm-level data), and ignoring the information from the **FOC for capital** (vs. using it in some form). These variables have both statistically and economically significant and systematic effects on the estimated elasticities. Finally we construct elasticities implied by correcting for publication bias and using best practice methodology (addressing all common problems in measuring the elasticity; Table 3).

Figure 3. Posterior coeff. distributions

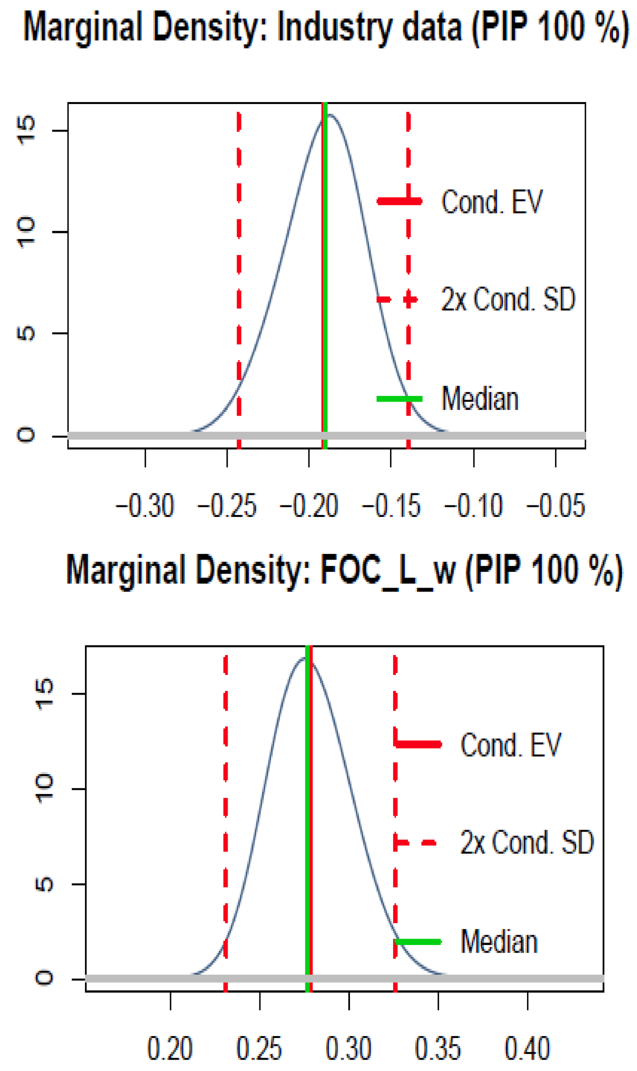


Table 2. Economic significance of key variables

	One-std.-dev. change		Maximum change	
	Effect on σ	% of best practice	Effect on σ	% of best practice
Standard error	0.117	39%	0.461	154%
Byproduct	-0.047	-16%	-0.152	-51%
Midpoint	0.056	19%	0.588	196%
Industry data	-0.095	-32%	-0.191	-64%
Database: OECD	-0.069	-23%	-0.277	-92%
Linear approx.	0.062	21%	0.235	78%
FOC_L_w	0.132	44%	0.278	93%
Normalized	-0.061	-20%	-0.277	-92%
Short-run σ	-0.083	-28%	-0.380	-127%
Net σ	-0.059	-20%	-0.376	-125%

Table 3. Estimates conditional on best practice

	Implied elasticity	95% confidence interval
Best practice	0.30	(-0.01, 0.60)
Short-run	-0.11	(-0.38, 0.15)
Net σ	-0.02	(-0.30, 0.25)
Country-level data	0.50	(0.18, 0.81)
Quarterly data	0.42	(0.08, 0.76)
Time series	0.25	(-0.10, 0.60)
Cross-sections	0.32	(0.07, 0.56)
System of FOCs	0.35	(0.07, 0.64)

Conclusions

The Cobb-Douglas production function contradicts the data. This is the result we obtain after analyzing the published estimates of the capital-labor substitution elasticity and correcting them for publication bias and misspecifications.

Please visit our website at **meta-analysis.cz/sigma** for, data, code, and the full paper.

Contact

Tomas Havranek
Charles University, Prague
tomas.havranek@ies-prague.org
www.meta-analysis.cz
www.tomashavranek.cz

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