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Why Did Productivity Fall So Much During the Great Depression?*

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ABSTRACT

Between 1929 and 1933, real output per adult fell over 30 percent and total factor productivity fell 18 percent. This productivity decrease is much larger than expected from just extrapolating the productivity decrease that typically occurs during recessions. This paper evaluates what factors may have caused this large decrease, including unmeasured factor utilization, changes in the composition of production, and increasing returns. I find that these factors combined explain less than one-third of the 18 percent decrease, and I conclude that the productivity decrease during the Great Depression remains a puzzle.

1. Introduction

Stan Engerman has made contributions to many areas of economics, including analyses of long-run productivity change (e.g. Engerman and Sokoloff (2000)). This paper honoring Stan's distinguished career studies a striking short-run productivity change: the large productivity decrease that occurred during the Great Depression.

Between 1929 and 1933, real output per adult fell over 30 percent, and total factor productivity (TFP) fell about 18 percent. This TFP decrease is much larger than expected from just extrapolating the TFP decrease that typically occurs during postwar recessions. During the average postwar downturn, output falls about two percent, and TFP falls 0.3 percent. This relationship suggests that TFP should have fallen only about four or five percent during the Depression, rather than 18 percent. It is unlikely that this decrease is due to "technological regress". But if this isn't the cause, then what factors are responsible? The Depression remains one of the most important and enduring mysteries in macroeconomics, and identifying the causes of this productivity decrease may shed new light on this period.

This paper presents productivity data from the Depression, and assesses how much of the decrease can be explained by five factors: changes in capacity utilization, changes in the quality of factor inputs, changes in the composition of production, labor hoarding, and increasing returns. All of these factors combined explain less than one-third of the 18 percent decrease. I conclude by suggesting that decreases in organizational capital - the knowledge and know-how firms use to organize production - may be a promising candidate for understanding this productivity decrease.

2. Aggregate Productivity during the Great Depression

The analysis uses Kendrick's (1961) TFP measure, which is the ratio of real GNP to an index of total factor input. This input measure is a factor-share weighted average of aggregate labor input and capital input. Table 1 shows Kendrick's TFP measure, output (Y), labor (L), and capital (K). TFP falls throughout the Depression, and is about 18 percent below its 1929 level in 1933. **(Table 1 about here)**

I begin by estimating how much of the productivity decrease is due to factor mismeasurement. Microeconomic studies indicate there were changes in capital utilization and in the average quality of capital and labor input during the Depression. Capital utilization fell, and the average quality of employed capital and labor rose as the least productive inputs were idled.

I adjust Kendrick's input measures to correct for these changes. Adjusting capital input requires estimating how much of the capital stock - measured in efficiency units - was idle during the period. Since there is no standard aggregate measure of this quantity, I estimate this fraction using manufacturing data from Bresnahan and Raff (1991). They report that the number of active manufacturing establishments fell one-third between 1929 and 1933. There are three reasons, however, why this decrease is too large of an estimate of the fraction of the aggregate capital stock idled. First, the manufacturing sector contracted more than average, which suggests that a greater fraction of manufacturing capital was idled. Second, Bresnahan and Raff report that the idled plants tended to be much smaller than those plants that remained active. Third, Bresnahan and Raff report that idled establishments tended to be the least productive establishments. This indicates that the idled plants - measured in efficiency units - were much smaller than operating plants. While a detailed analysis of idled capital is beyond the scope of this paper, these three facts suggest that a plausible estimate for the fraction of the aggregate capital stock idled is around 15-20 percent.

I next examine changes in the average quality of labor input during the Depression. I focus on two types of quality changes: *intersectoral* changes and *intrasectoral* changes.

Intersectoral changes arise from shifts in the sectoral composition of production. These shifts change average labor quality because labor quality varies by sector. For example, agricultural workers at that time were less skilled, on average, than manufacturing workers. Kendrick's labor measure adjusts for this source of quality change by multiplying sectoral hours by the sectoral wage.

Intrasectoral changes arise through changes in the average quality of individual workers within sectors. Kendrick's labor measure does not adjust for this type of quality change. Lebergott (1993) reports that employee quality rose during the depression, as employment loss was concentrated among low-wage workers, and the most productive workers worked the longest shifts. This suggests that the average quality of individuals who continued to work during the Depression was higher than the average quality of individuals working before the

Depression. Cole and Ohanian (2000) use macro data to estimate that the quality of workers may have increased by 15-18 percent during the Depression. Lebergott (1993) reports micro data that suggests the average quality of workers at the two largest firms in the electrical equipment industry - General Electric and Westinghouse - rose about 10 percent during just the first two years of the Depression. Given these estimates, I assume that average worker quality rose seven percent during the Depression. This is a more conservative adjustment than either of the two preceding estimates, and thus will produce a relatively small revision to Kendrick's TFP measure.

I recompute TFP with these capital and labor adjustments. I find that these adjustments explain only about two percentage points of the 18 percent TFP decrease. This is because the change in labor input, multiplied by labor's share, offsets much of the change in capital input, multiplied by capital's relatively small share.

3. Sectoral Productivity during the Great Depression

Since these factor mis-measurements do not explain much of the decrease in aggregate TFP, I now examine sectoral data to see if less aggregated productivity measures also fell during the Depression. The second column of Table 2 shows productivity in 1933, relative to 1929, for the five sectors reported by Kendrick. These five sectors account for about 50 percent of 1929 GNP. The data show that sectoral productivities fall much less than aggregate productivity. Manufacturing and railroads are the only sectors that show substantial TFP declines, and these decreases are only about half as large as the decline in aggregate TFP.

(Table 2 about here)

The fact that aggregate productivity fell more than these sectoral productivities raises the possibility that changes in the composition of production from high value of marginal product sectors to low value of marginal product sectors contributed to the aggregate TFP decrease. Relative wage and employment data are also consistent with this view. The third column of Table 2 shows sectoral employment in 1933 relative to 1929, while the fourth column shows the 1929 sectoral wage relative to the 1929 average wage. These data show that agriculture - which pays low wages - declined very little, while manufacturing and mining - which pay high wages - declined substantially.

How much did this change in the composition of output decrease aggregate TFP? Kendrick's aggregate TFP measure tries to correct for these compositional effects by multiplying sectoral inputs by sectoral factor prices. He estimates that compositional shifts reduced aggregate TFP by about 2.5 percent. Without the compositional correction, Kendrick's aggregate TFP measure would have decreased by 20.5 percent rather than 18 percent.

Kendrick's 2.5 percent adjustment seems small, however, relative to the large expansion of the low-value agricultural sector. As a robustness check, I independently estimate the size of the compositional effect. I begin by constructing a model to understand the connection between sectoral productivities and aggregate TFP. The model specifies that sectoral outputs are produced from constant returns to scale production functions using capital and labor that differ only by their TFP level, which is denoted as A_{it}:

$$(1) \qquad Y_{it} = A_{it}F(K_{it}, L_{it})$$

Aggregate output is the sum of sectoral outputs multiplied by base-year sectoral prices, which are denoted as p_i :

$$(2) \qquad Y_t = \sum_i p_i Y_{it}$$

With these assumptions, "aggregate TFP" is a weighted average of sectoral productivities multiplied by relative prices, with weights equal to each sector's share of total labor:

$$(3) \qquad A_t = \sum_i \left\{ p_i A_{it} \left(\frac{L_{it}}{\sum_i L_{it}} \right) \right\}$$

This equation can be used with price, productivity, and labor data to estimate the compositional effect. To do this, however, I need a proxy for the relative price terms. I substitute for this term using wage data. I use this proxy since profit maximization implies that the sectoral relative price is equal to the sectoral relative wage divided by the sector's marginal product of labor. Unfortunately, the data required to construct the marginal products are not all available, so I proxy for the relative price using only the relative wage. This proxy will overstate the compositional effect because the marginal product of labor is probably above average in high wage sectors.

I now estimate the effect of compositional shifts by calculating aggregate TFP holding sectoral productivity levels fixed at their respective 1929 levels, and changing labor inputs as in the data. I use wage and empoyment data for all sectors from U.S. Bureau of the Census (1975). I estimate that changes in the composition of production reduced aggregate TFP by about 4.5 percent. Since this estimate is probably biased upwards, it seems unlikely that compositional effects are bigger than Kendrick's 2.5 percent correction.

This analysis suggests that Kendrick's measure of aggregate TFP adequately corrects for compositional shifts, and that the sectors for which Kendrick does not report productivity - construction, finance/insurance/real estate, services, wholesale and retail trade, and government - account for most of the 18 percent decrease in aggregate TFP. This residual productivity decrease is likely due to lower productivity in the remaining sectors. The other possible cause - a compositional shift from the highest-valued added to the lowest-value added sectors within the residual category - is unlikely because wage differences are small in these sectors. This suggests that accounting for the 18 percent aggregate productivity decrease requires that productivity fell more than 25 percent, on average, in Kendrick's residual sectors.

4. Alternative Explanations

Why did productivity fall so much in some sectors - manufacturing, railroads and in the residual categories - but not in others? I now briefly consider two other explanations for lower productivity: labor hoarding and increasing returns to scale. Bernanke and Parkinson (1991) cite these factors as possible explanations for productivity decreases in manufacturing industries during the Depression.

Economists often advance labor hoarding as an explanation for low productivity during recessions. The standard labor hoarding thesis is that the firing and hiring costs associated with temporary layoffs exceeds the cost of "hoarding" workers - reducing worker utilization relative to paid hours. This utilization decrease reduces measured productivity.

The duration of the Depression, however, raises questions about the plausibility of the labor hoarding explanation. It is difficult to reconcile the labor hoarding thesis - which is based on the temporary nature of recessions - with a major depression that lasted well over a decade. It seems unlikely that firms hoarded workers because they mistakenly expected the Depression to end quickly; consumption data suggests that the Depression was expected to last a long time. Purchases of nondurable goods and services fell sharply during the first year of the Depression. Viewed within the lens of Milton Friedman's permanent income hypothesis, this large decrease indicates that households viewed their permanent income falling significantly at the start of the Depression. This is consistent with a large and very persistent negative shock, rather than a transitory shock. A challenge for the labor hoarding view is to explain why firms hoarded labor during such a long and deep depression, and to explain why labor hoarding did not affect all sectors.

Increasing returns to scale is an alternative explanation for low productivity during postwar recessions. With increasing returns, a reduction in factor inputs will show up as lower productivity under a standard Solow residual accounting exercise based on constant returns to scale. A number of recent econometric studies, however, estimate constant returns to scale at both aggregated and disaggregated levels with small standard errors. These findings present strong evidence against big increasing returns, and suggest that only about three percentage points of the 18 percent productivity decrease could be plausibly explained by this factor.

In summary, I find that all of these factors combined account for only about five percentage points of the 18 percent decrease. This leads me to consider the alternative view that lower production efficiency contributed to the productivity decrease. One possibility is that a decrease in *organizational capital* - the knowledge and know-how firms use to organize production - reduced efficiency (see Prescott and Visscher (1980)). Changes in organizational capital might be a promising explanation because this factor is quantitatively important, and it is plausible that it fell during the Depression. Regarding its quantitative importance, Atkeson and Kehoe (2000) use a version of the neoclassical growth model and estimate that organizational capital in the U.S. is about 40 percent as large as the total physical capital stock. There are a number of reasons why this large stock of capital could have fallen, including breakdowns in relationships with suppliers that lead to changes in production plans, and breakdowns in customer relationships that lead to changes in marketing, distribution and inventory plans.

These breakdowns can reduce efficiency by leading managers to shift time away from production and into search activities. For example, failure of intermediate goods suppliers could reduce efficiency by requiring managers to search for new suppliers. This search activity would lower efficiency by reducing managerial labor input to organizing and planning production. Similar reasoning suggests that failures of either wholesalers or retail customers could reduce efficiency by leading managers to substitute out of production and into search activities.

Breakdowns in these relationships could also reduce efficiency by leading firms to adopt different technologies that initially are operated inefficiently. Atkeson and Kehoe (2000) present manufacturing plant-level data that supports this hypothesis. They find that the productivity of plants adopting leading edge technologies is initially lower than the productivity of much older plants. This suggests that organizational capital is technology-specific and that firms must accumulate new organizational capital to efficiently operate new technologies.

5. Conclusion

The usual suspects for explaining procyclical productivity - changes in capital utilization, shifts in production from high productivity to low productivity sectors, labor hoarding, and increasing returns - explain only about five percentage points of the 18 percent decrease in aggregate productivity. I conclude that the Great Depression productivity puzzle remains largely unsolved.

This conclusion suggests two alternative interpretations of the productivity puzzle. One conclusion is that alternative forms of measurement error are responsible for the productivity decreases. Measurement error hypotheses tend to raise two possibilities: either that output fell significantly less than measured - which would imply that the Depression was less severe than previously thought - or that inputs fell more than measured - which would deepen the puzzle of why employment fell so much during the Depression.

The other interpretation is that lower production efficiency contributed to these productivity decreases. One explanation of the lower efficiency view is that the Depression reduced firm-specific organizational capital by disrupting normal production, distribution, marketing, and inventory plans.

These two different interpretations of the productivity puzzle suggest very different views about the nature of the Great Depression, and solving this puzzle may considerably advance our understanding of this fascinating period . More research is needed, however, to determine how much of these productivity decreases is due to changes in efficiency - either through lower organizational capital or other shocks to efficiency - and how much is due to measurement error or other factors. A major challenge is to explain not only why measured productivity fell, but why productivity change varied so much across sectors.

6. References

Atkeson, Andrew and Kehoe, Patrick "Industry Evolution and Transition: The Role of Information Capital." Mimeo, Federal Reserve Bank of Minneapolis, 2000.

Bernanke, Ben and Parkinson, Martin "Procyclical Labor Productivity and Competing Theories of the Business Cycle: Some Evidence from Interwar U.S. Manufacturing Industries." The journal of political economy 99(3), 1991, pp. 439-59.

Bresnahan, Timothy and Raff, Daniel "Intra-industry Heterogeneity and the Great Depression: The American Motor Vehicles Industry, 1929-1935." Journal of economic history 51(2), 1991, pp. 317-31.

Cole, Harold and Ohanian, Lee E. "Re-Examining the Contributions of Money and Banking Shocks to the U.S. Great Depression," in Ben Bernanke and Kenneth Rogoff, eds., NBER macroeconomics annual, Cambridge, MA: MIT Press, 2001, forthcoming.

Engerman, Stanley, and Sokoloff, Kenneth "Technology and Industrialization, 1790-1914" in Stanley Engerman and Robert Gallman, eds., The cambridge economic history of the United States, vol. II, Cambridge, MA: Cambridge University Press, 2000, pp. 367-402.

Kendrick, John Productivity trends in the United States. Princeton, NJ: Princeton University Press.

Lebergott, Stanley "Wage Rigidity in the Great Depression: Concept or Phrase?" Mimeo, Wesleyan University, 1993.

Prescott, Edward and Vischer, Michael "Organization Capital." The journal of political economy 88(3), 1980, pp. 446-461.

U.S. Bureau of the Census, Department of Commerce. Historical statistics of the United States, Colonial times to 1970. Washington, DC: U.S. Government Printing Office, 1975.

Tables

Table 1

Output, Inputs, and TFP During the Great Depression

(1929 = 100)

Year	Y	L	K	TFP
1930	89.6	92.7	102.5	94.2
1931	80.7	83.7	103.2	91.2
1932	66.9	73.3	101.4	83.4
1933	65.3	73.5	98.4	81.9

Table 2

Sectoral Productivity and Compositional Shifts in Production

	TFP	1933 Labor	1929 Relative Wage
Mfg.	91.5	59.7	127.2
Farm	104.5	97.4	38.2
Mining	99.5	55.2	162.5
Railroads	90.2	51.3	119.7
Communications/Utilities	100.9	62.1	114.3

Footnote

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