The Lasting Damage from the Financial Crisis to U.S. Productivity

Michael Redmond and Willem Van Zandweghe

The financial crisis and recession of 2007–09 left deep scars on the U.S. economy. Output of goods and services declined sharply during the crisis, and while output began to grow afterward, its level has not caught up to its pre-crisis trend. Likewise, total factor productivity, a key source of output growth in the long run, declined and has remained on a lower trajectory than before the crisis.

Tighter credit conditions may have contributed to these declines. Obtaining credit was more difficult and expensive for firms during the crisis, as widespread fear and uncertainty drove lenders to raise interest rates and lend more cautiously. The reduced credit supply may have prevented firms from investing in innovation and creating new jobs and prevented new firms from entering the market. In this way, tighter credit conditions may have lowered total factor productivity—and, consequently, real activity.

We examine the empirical relationship between credit conditions and total factor productivity growth during the financial crisis. Our empirical analysis shows the crisis indeed altered this relationship. During normal times, total factor productivity growth fluctuates over the business cycle along with changes in the intensity with which available labor and capital are used; credit conditions are unimportant.

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During the crisis, however, distressed credit markets and tighter lending conditions were significant drags on total factor productivity growth. Because productivity's sensitivity to credit conditions once again diminished after the crisis, the post-crisis easing of credit conditions did not boost productivity growth. As a result, the financial crisis left productivity, and therefore output, on a lower trajectory. Adverse credit conditions appear to have dampened total factor productivity growth by curtailing productivity-boosting innovation during the crisis rather than by hampering the efficient allocation of the economy's productive resources through reduced creation and destruction of firms and jobs.

Section I describes the behavior of credit conditions and productivity during the financial crisis. Section II provides empirical evidence of the relationship between productivity and credit conditions. Section III examines the relationships between credit conditions and two factors that affect productivity: innovation or resource reallocation.

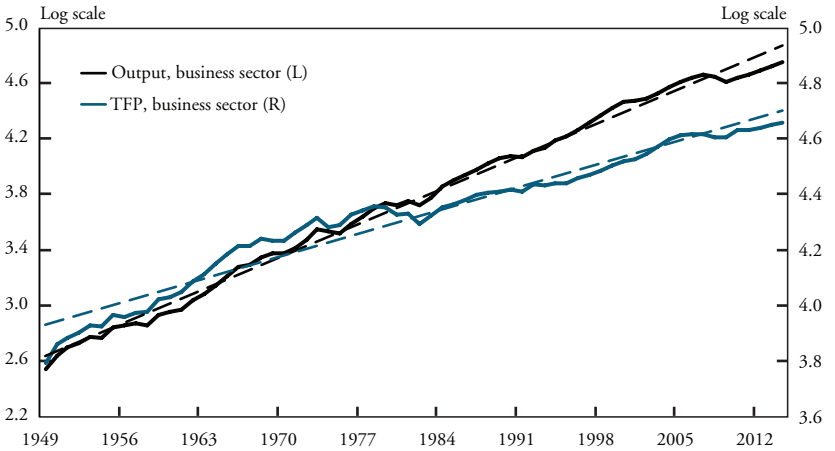
I. Total Factor Productivity in the Financial Crisis

The financial crisis and associated recession triggered a persistent drop in output below its long-run trend, due in part to a drop in total factor productivity (TFP). TFP declined as credit conditions tightened during most of the crisis; when credit conditions subsequently eased, TFP partially rebounded, though it remains below its long-run trend.

Chart 1 displays output in the business sector (solid black line) along with its long-run trend (dashed black line). In 2008 and 2009, output fell below the trend line; after the crisis subsided, output began to rise but remained well below the trend line. Indeed, by 2014, the gap between output and its long-run trend had widened somewhat further. Gross domestic product, which includes the government sector, declined less than business sector output from 2008 to 2009, but was slower to recover after the crisis. Many studies find output frequently does not rebound to its pre-crisis trend (Ball; Blanchard, Cerutti and Summers; Hall; and Reifschneider, Wascher, and Wilcox), perhaps because financial crises have long-lasting effects (Cerra and Saxena; Reinhart and Rogoff; Queralto; Martin, Munyan, and Wilson).[1]

Similar to the path of output, TFP fell below its trend line during the financial crisis and has remained there since. Chart 1 shows the historical trajectory of TFP (solid blue line) along with its long-run

Chart 1
Output and Productivity



Note: Dashed lines represent long-run trends and are estimated as linear regression lines.
Sources: Bureau of Labor Statistics and Haver Analytics.

trend line (dashed blue line). TFP declined in 2008 and 2009 before resuming modest growth from 2010 to 2014, thus leaving the level of TFP on a trajectory below its long-run trend.

The similar paths of output and TFP suggest the decline in TFP may have played a substantial role in the decline in output. As a matter of accounting, output growth can be attributed to growth in labor, capital, or TFP. The latter consists of productivity gains that allow more output to be produced without increasing the labor and capital used to produce it. These productivity gains can occur for several reasons, such as technological innovation, better resource allocation, a more intense use of available production factors, or changes in regulation, tax policies, and competitiveness.

Productivity and credit conditions in the financial crisis

Declining TFP appears to have weighed on output during the financial crisis—but what led to the decline in TFP? We home in on credit conditions as the primary suspect. Economists have cited theoretical arguments in relating the persistent decline in TFP to the sharp tightening of credit conditions during the financial crisis. Theoretical models predict a clear relationship between financial conditions and innovation, and recent analyses apply these theories to shed light on

the macroeconomic effects of the recent financial crisis (Ikeda and Kurozumi; Guerron-Quintana and Jinnai; Anzoategui, Comin, Gertler, and Martinez; and Garcia-Macia). Other theoretical work highlights a connection between financial conditions and resource reallocation (Petrosky-Nadeau). Both innovation and resource reallocation are key determinants of TFP.

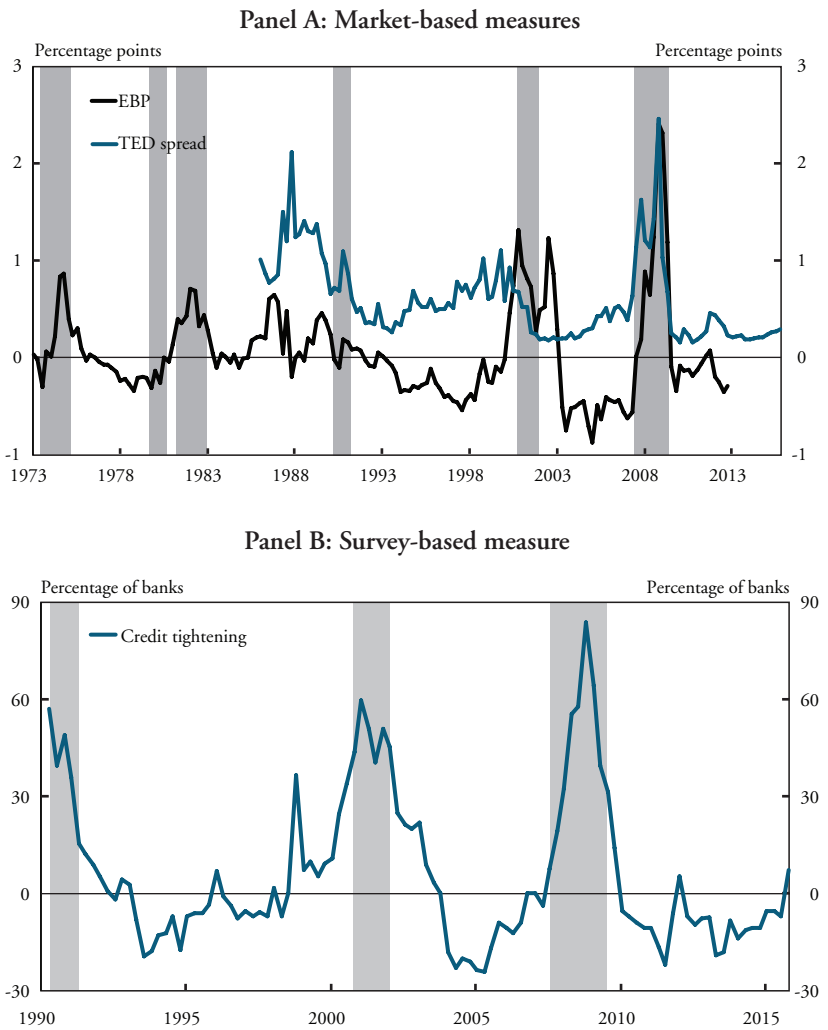
Chart 2 shows three measures of credit supply conditions, two market-based and one survey-based. The first market-based measure is the excess bond premium (EBP) of Gilchrist and Zakrajšek, which measures credit supply conditions as deviations in the pricing of corporate bonds relative to the issuer's measured default risk (Panel A, black line). The authors use firm-level data to account for firms' default risk in corporate bond credit spreads, so the remaining portion (the EBP) captures the compensation investors demand for bearing exposure to corporate credit risk. The second market-based measure is the spread between three-month eurodollar deposits and Treasury bills, or the TED spread (Panel A, blue line). The TED spread captures the cost of interbank borrowing measured as the difference between the rates at which banks can borrow from other banks and the risk-free rate.[2] A rising EBP or TED spread suggests lenders have reduced the supply of credit (thus raising its cost) because they perceive increased credit risk. A sudden sharp rise in the cost of credit can effectively limit access to credit for many firms.

A third, survey-based measure displays the net percentage of banks tightening conditions for commercial and industrial loans to large firms, as captured by the Federal Reserve's Senior Loan Officers Opinion Survey (Panel B). This measure is a diffusion index, and thus provides a more qualitative reading on changes in credit conditions than the previous two. All three measures of credit conditions rose sharply during the financial crisis, as the distress in credit markets pushed credit conditions and bank lending standards to historically tight levels.

Credit supply conditions had a close relationship with TFP during the last recession. Panels A and B of Chart 3 display the market-based and survey-based measures of credit conditions, respectively, from the first quarter of the recession, 2007:Q4, to the last quarter of the recession, 2009:Q2.[3] The panels also show quarterly TFP, available from Fernald, as a blue line. Both panels show a negative relationship

Chart 2

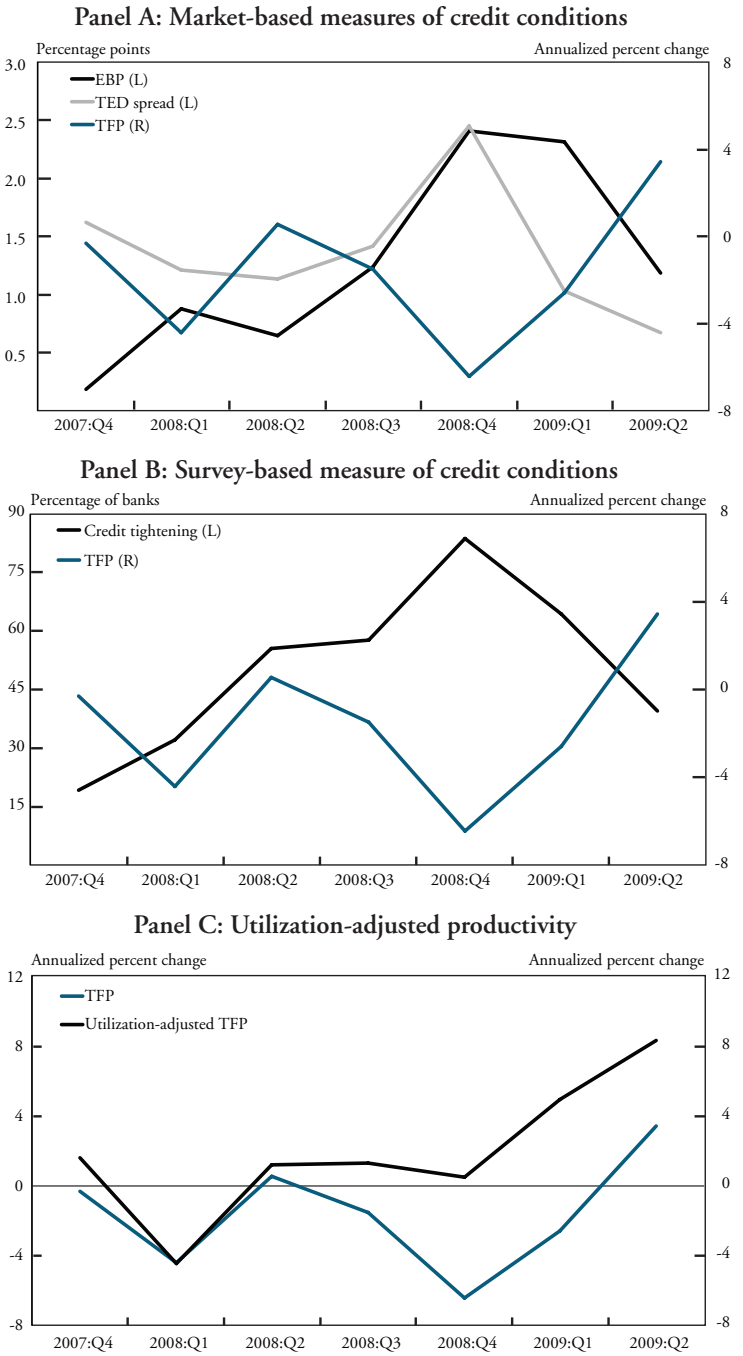
Measures of Credit Conditions



Note: Gray bars denote NBER-defined recessions.
Sources: Federal Reserve, Federal Reserve Bank of St. Louis FRED, Gilchrist and Zakrajšek, and Haver Analytics.

Chart 3

Credit Conditions and Productivity in the Great Recession



Sources: Federal Reserve, Fernald, Federal Reserve Bank of St. Louis FRED, Gilchrist and Zakrajšek, and Haver Analytics.

between credit conditions and TFP during the recession. During the first year of the recession, TFP slowed as credit conditions worsened. But in the last six months of the recession, TFP growth resumed as access to credit began to ease.[4]

But could the decline in TFP during the recession merely reflect a less intense use of labor and capital? After all, indicators of the intensity with which firms use their production factors, such as the Federal Reserve Board's industrial capacity utilization, declined sharply over the same period, suggesting firms idled machinery and required less effort from workers. These responses to the economic downturn, commonly referred to as declines in factor utilization, would result in lower TFP, as they reduce output but do not change labor and capital. To gauge the structural component of TFP, Fernald and Matoba remove the fluctuations in factor utilization from TFP growth and find that utilization-adjusted TFP actually rose during the recession. Panel C of Chart 3 shows Fernald's measure of utilization-adjusted TFP (gray line) diverged sharply from the unadjusted measure during the height of the recession, as factor utilization fell sharply. A decline in unobserved worker effort and capital utilization during downturns is consistent with the idea that firms adjust labor on all margins—paid hours as well as unobserved effort and capital utilization—and helps explain the procyclical pattern of labor productivity that characterized recessions until the early 1980s (Biddle).

However, the last recession differed from past recessions in that it was associated with a severe financial crisis. The collapse of product demand and the lack of access to credit forced firms to cut paid hours sharply in a bid to survive. Keeping nonessential workers on the payroll while sharply reducing their labor effort was likely not viable for many firms. Indeed, Lazear, Shaw, and Stanton find evidence that worker effort actually increased during the last recession. Thus, measures of factor utilization that assume the relationship between paid hours and unobserved effort was unchanged in the last recession—such as Fernald's measure—could exaggerate factor utilization's influence on TFP growth.[5]

Similarly, the Federal Reserve Board's measure of capacity utilization may also exaggerate the decline in worker effort during the last recession. The Board's measure largely reflects capital utilization, which is expected to decline as firms idle factories and machinery, even if workers in the remaining shifts raise their labor effort. For the economy as a whole, labor effort, not capital utilization, should dominate factor

utilization, as the income share of labor exceeds that of capital. Therefore, the preceding measures of factor utilization and capacity utilization arguably exaggerate the decline in worker effort during the last recession. For these reasons, we follow Hall in viewing the unadjusted measure of TFP as more relevant.

Innovation and resource reallocation

If credit conditions are responsible for the decline in TFP during the financial crisis, through which channels could this have happened? Two channels are consistent with the theoretical literature: a reduction in credit availability could have hurt TFP by curbing innovation or by hampering resource reallocation, two key contributors to productivity growth.

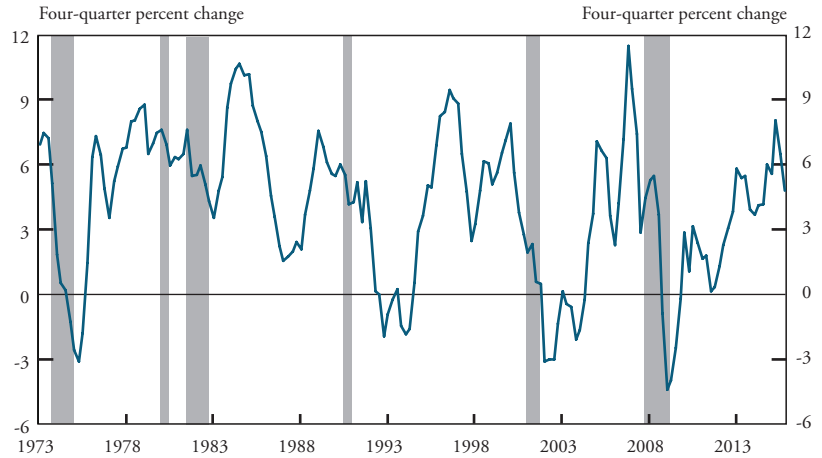
First, a lack of access to credit could have curbed innovation if it caused firms to cancel or postpone research and development (R&D) projects. Chart 4 shows real R&D growth in the private sector collapsed during the recession from a rate of more than 4 percent in the fourth quarter of 2007 to a rate of –4 percent in the second quarter of 2009. R&D growth started slowing in the beginning of 2007; including that period, the reversal in R&D growth from the beginning of 2007 to the beginning of 2009 was the largest since the 1960s.

Lower R&D spending likely reduced innovation and its productivity-enhancing effects on the economy. A large body of empirical literature suggests R&D spending has a significant positive effect on productivity growth (see Congressional Budget Office for a review). Moreover, TFP could have responded quickly to the decline in R&D spending during the crisis. While basic research may not be commercialized for many years, much of private R&D spending consists of product development such as model-year updates of manufactured goods. In addition, TFP could have responded quickly to a downturn in R&D to the extent such investments were correlated with intangible investments that went unmeasured.

Second, a lack of access to credit could have hampered resource reallocation by preventing the creation of new firms and jobs. Business startups and the jobs they generate are often highly productive, as such firms bring new ideas to market and implement advanced production processes. For instance, Haltiwanger, Faberman, and Jarmin find new

Chart 4

Private Investment in R&D



Note: Gray bars denote NBER-defined recessions.
Sources: Bureau of Economic Analysis and Haver Analytics.

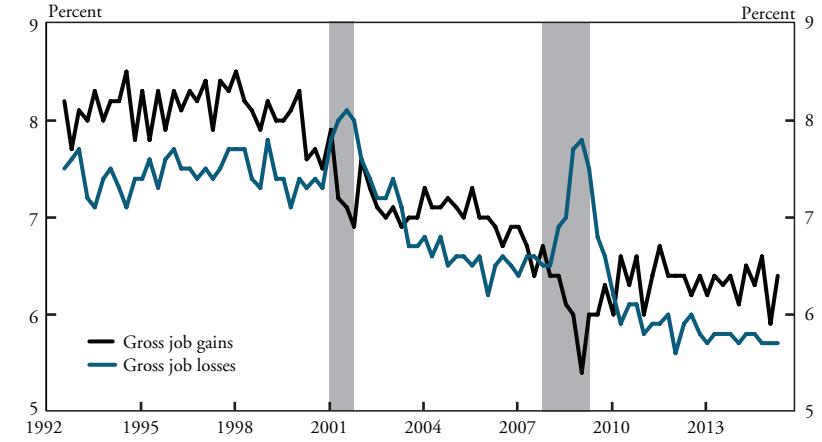
firms make a substantial contribution to job creation. By stunting this type of reallocation, reduced access to credit could lower productivity. Chart 5 shows the rate of gross job gains in the private sector (expressed as a percent of employment) dropped steeply during the recession, reaching a trough of 5.4 percent in the first quarter of 2009. Although the rate of job gains subsequently recovered, its average since the end of the recession (6.3 percent) has remained well below its average during the expansion in the 2000s (7.1 percent).

However, reduced access to credit may not always have a negative effect on productivity. Indeed, a tightening of credit conditions could have a positive effect on aggregate productivity by leading firms to eliminate the least productive jobs and forcing the least productive firms out of business. The blue line in Chart 5 shows the rate of gross job losses surged during the recession, peaked at 7.8 percent in the first quarter of 2009, and stabilized at a low level after the recession ended. Consequently, the rate of gross job losses has been lower on average during the current expansion (5.9 percent) than during the previous one (6.8 percent).[6]

On balance, reallocation remained relatively stable during the recession, as the negative effects of fewer new jobs and firm entries offset the positive effects of more job losses and firm exits. Chart 6 shows the rate of job reallocation, which is the sum of the rates of gross job gains

Chart 5

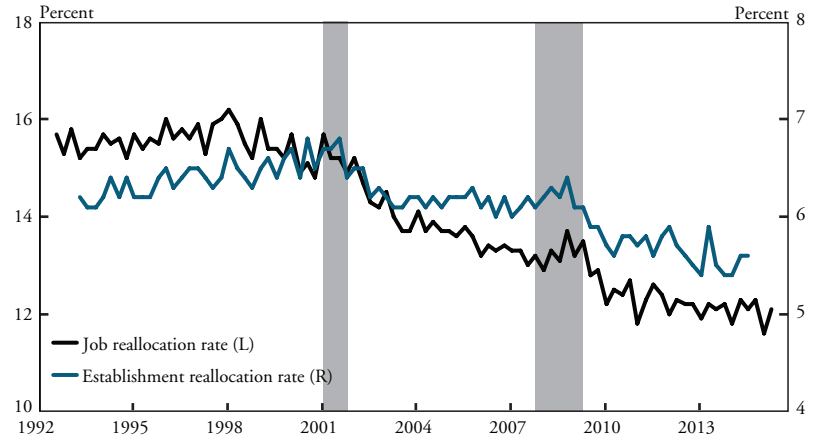
Job Gains and Losses



Note: Gray bars denote NBER-defined recessions.
Sources: Bureau of Labor Statistics and Haver Analytics.

Chart 6

Job and Establishment Reallocation



Note: Gray bars denote NBER-defined recessions.
Sources: Bureau of Labor Statistics and Haver Analytics.

and losses, and the rate of establishment reallocation, which is the sum of the rates of births of and deaths of business establishments. The rate of job reallocation ticked up from 13.2 percent in the fourth quarter of 2007 to 13.5 percent in the second quarter of 2009, as the increase in the rate of gross job losses more than offset the decline in the rate of gross job gains. The rate of establishment reallocation stood at 6.1 percent in the first and last quarters of the recession, though both reallocation rates continued to slip in the recession's aftermath.

In sum, the severe tightening in credit conditions during the financial crisis may have lowered TFP by impeding innovation and resource reallocation. The next two sections investigate these hypotheses more formally—first, by establishing a relationship between credit conditions and TFP growth, and second, by examining the role of credit conditions in innovation and resource reallocation.

II. Empirical Analysis of Credit Conditions and TFP

To examine whether tight credit supply impeded productivity growth during the financial crisis, we estimate a regression model that quantifies the relationship between TFP growth and credit conditions. The results suggest a tight credit supply during the crisis temporarily restrained the growth rate of TFP, leaving a lasting mark on the level of productivity.

The regression model relates TFP growth in a quarter t (y_t) to three explanatory variables. The first two variables, a measure of credit conditions in the current quarter (x_t) and the previous quarter (x_{t-1}), allow us to account for the immediate and lagged influence of credit conditions on TFP growth. The third variable, a measure of factor utilization (u_t), allows us to control for utilization-driven fluctuations in TFP growth, as the series of TFP growth we use in the estimation is not utilization-adjusted. In addition, the model contains a constant term and an error term (ε_t) that captures unexplained variation in TFP growth.

One challenge in constructing such a model is that the financial crisis may have affected the usual economic relationships between the variables. For example, the propagation of shocks to the economy could have changed because the economy was highly leveraged, allowing small shocks to have large effects on the real economy; Ng and Wright emphasize this balance sheet effect.[7] Furthermore, policy responses may

have been weaker than usual relative to the magnitude of the shock, as monetary policy was constrained by the zero lower bound on interest rates. To account for these possibilities, we allow the coefficients on each variable and the constant term to differ during the crisis. Specifically, the regression model is as follows:

$$y_t = a_f + a_n d_{n,t} + b_{f,0}\left(x_t d_{f,t}\right) + b_{f,1}\left(x_{t-1} d_{f,t}\right) + b_{n,0}\left(x_t d_{n,t}\right) + b_{n,1}\left(x_{t-1} d_{n,t}\right) + c_f\left(u_t d_{f,t}\right) + c_n\left(u_t d_{n,t}\right) + \varepsilon_t$$

where $d_{f,t}$ is a dummy variable that takes a value of 1 in the quarters of the financial crisis and recession (from the fourth quarter of 2007 to the second quarter of 2009) and 0 in other quarters, and $d_{n,t}$ is its complement (that is, $d_{n,t} = 1 - d_{f,t}$).[8] The coefficients with the subscript f (that is, a_f, $b_{f,0}$, $b_{f,1}$, and c_f) predict TFP growth based on credit conditions and factor utilization during the financial crisis. The coefficients with the subscript n (that is, $b_{n,0}$, $b_{n,1}$, and c_n) predict TFP growth during normal times (except for the constant term that is the sum of the coefficients with subscripts f and n—that is, $a_f + a_n$). We omit lags of TFP growth from the list of regressors because they were not statistically significant.

To gauge the robustness of the estimation results, we use the various measures of credit conditions and factor utilization introduced in the previous section. Specifically, for credit conditions, we use the EBP, the TED spread, and the survey-based measure of bank lending conditions. For utilization, we use Fernald's measure of factor utilization and the Federal Reserve Board's measure of capacity utilization. The quarterly series of TFP growth is also obtained from Fernald. We estimate the model using ordinary least squares; regressor endogeneity tests indicate that the exogeneity assumption for ordinary least squares is satisfied, as an instrumental variables estimation yields similar results.[9] Because the financial crisis was a period of high volatility, inference relies on heteroscedasticity and autocorrelation consistent (HAC) standard errors.

The regression analysis indicates that during the financial crisis, the sharp deterioration in credit conditions is associated with a significant slowing of TFP growth; during normal times, there is no significant association. Table 1 summarizes the estimation results.

Table 1
Regression Results for Productivity Growth

Dependent variable: TFP growth						
	(1)	(2)	(3)	(4)	(5)	(6)
Measures (x,u)	(ebp, facutil)	(ebp, caputil)	(ted, facutil)	(ted, caputil)	(sloos, facutil)	(sloos, caputil)
x*df	-5.3872***	-6.8266***	-4.9578***	-4.6824***	-0.1293***	-0.0679**
x(-1)*df	3.3696***	2.8203***	-4.4154***	-4.2118***	0.1167***	0.2609***
x*dn	-1.8757*	-1.7675*	-0.3306	-0.6082	-0.0172	-0.0037
x(-1)*dn	1.5902*	2.1118**	0.2239	0.2966	0.0247	0.0207
u*df	-0.2349***	-1.0622***	-0.3234***	-0.3023**	0.5013*	2.8877***
u*dn	0.4367***	1.0443***	0.2848**	0.7159***	0.2998**	0.8219***
Sample	1973:Q2–2012:Q4	1973:Q2–2012:Q4	1986:Q2–2015:Q4	1986:Q2–2015:Q4	1990:Q3–2015:Q4	1990:Q3–2015:Q4
Observations	159	159	119	119	102	102
R^2	0.2925	0.3268	0.1876	0.2014	0.1784	0.2042
x*df+x(-1)*df	-2.0176***	-4.0062***	-9.3733***	-8.8942***	-0.0126	0.1930*
x*dn+x(-1)*dn	-0.2856	0.3443	-0.1066	-0.3116	0.0075	0.0170

*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

Notes: Regressions include constant terms for the financial crisis and normal times (not reported). Inference is based on HAC standard errors.

Columns 1 and 2 show that a rise in the EBP may have a persistent dampening effect on TFP. During both the financial crisis and normal times, a rise in the EBP is associated with an immediate decline in TFP growth; however, some of the decline is offset in the following quarter, as indicated by the positive estimated coefficient on the lagged EBP (denoted *x*(-1)**df* and *x*(-1)**dn* in the table). The cumulative effect of a 1 percentage point rise in the EBP can be gauged by the sum of the estimated coefficients on the current and the lagged credit variable, which is shown in the last two rows. During the financial crisis, the sum is negative and statistically significant, indicating the rise in the EBP during the crisis dampened TFP growth. In contrast, during normal times, the sum is not significantly different from zero, indicating changes in credit conditions did not affect TFP growth outside of the financial crisis.

Columns 3 and 4 show the TED spread has an even stronger negative association with TFP growth. The rising TED spread during the financial crisis is associated with slower TFP growth, both

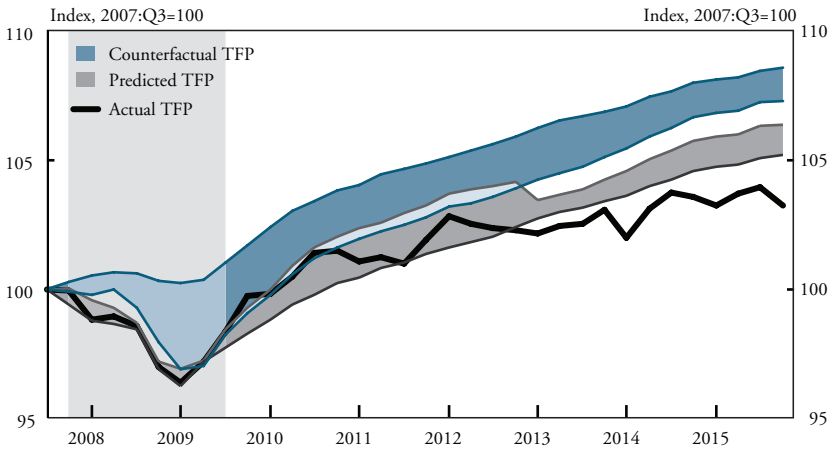
contemporaneously and in the next quarter. These estimation results suggest tightening credit conditions exerted strong downward pressure on productivity growth. Once again, this conclusion holds only for the financial crisis, as the sum of the estimated coefficients on the current and lagged TED spread is not significantly different from zero during normal times.

Columns 5 and 6 report the results for the survey-based measure of credit conditions, denoted *sloos*. The estimated coefficients on the current and lagged credit measure largely offset one another, so their sum is barely significantly different from zero if at all. This suggests that tightening conditions for bank loans did *not* restrain TFP growth even during the financial crisis. This finding conflicts with that of the market-based measures; however, it seems reasonable to place less weight on the survey-based measure because of its qualitative characteristics.

The joint results obtained with the three measures of credit conditions support the conclusion that the financial crisis acted as a brake on TFP growth due to the distress in credit markets and the heightened sensitivity of TFP growth to credit conditions. That is, both a large shock and an altered propagation of that shock to the economy likely played crucial roles for the path of productivity. The temporary decline in the growth rate of TFP during the crisis permanently reduced the level of TFP, as TFP growth did not receive a subsequent boost when credit conditions and productivity's sensitivity to those conditions normalized. As a result, TFP remained on a lower trajectory during the economic recovery.

The estimation results for the utilization variables indicate factor or capacity utilization did not dampen TFP growth during the financial crisis as it did during past recessions. The regressions show a positive association during normal times, indicating that a less intense use of available labor and capital lowered productivity in downturns—the usual "labor hoarding" effect of recessions on productivity. During the financial crisis, however, the estimated coefficients on factor utilization and capacity utilization—denoted *facutil* and *caputil*, respectively—turn negative, with the exception of the regressions using the survey-based measure of credit conditions. Taken literally, the negative estimated coefficients suggest that lower utilization boosted TFP growth during the crisis. More realistically, however, the boost to TFP growth

Chart 7
Counterfactual Path of Productivity



Notes: The gray shaded area denotes the range of TFP paths predicted by the regressions in Table 1, and the blue shaded area denotes the counterfactual range of TFP paths predicted by the regressions in Table 1 assuming the estimated coefficients during the financial crisis are the same as the estimated coefficients during normal times. Gray bar denotes NBER-defined recession.
Sources: Fernald and authors' calculations.

from the utilization factor likely resulted from the increase in worker effort during the crisis documented by Lazear, Shaw, and Stanton. In sum, the results suggest TFP growth did not slow because of declining utilization during the crisis.

To assess how TFP would have evolved had the financial crisis not affected it, we perform a counterfactual exercise. Chart 7 shows the historical path of TFP (black line) along with a range of predictions of TFP from the onset of the financial crisis onward (gray shaded region) generated by the six regressions summarized in Table 1. The regressions effectively capture the drop and rebound in TFP through 2012, but they fail to account for the shallower path of TFP since then. The blue shaded band shows the range of counterfactual paths TFP might have followed had its relationship with credit conditions and utilization during the financial crisis remained the same as in normal times. The counterfactual suggests TFP would have declined in the recession due to the observed drop in utilization even though the distress in credit markets would not have had a visible effect. However, as utilization normalized, the effect on TFP would have dissipated, leaving the level of TFP noticeably higher by the end of 2015. This exercise indicates that by cutting firms' ac-

cess to credit and upending the usual macroeconomic relationships, the financial crisis had a lasting effect on productivity.

III. Channels from Credit Conditions to TFP

As credit conditions likely had an adverse effect on TFP growth during the crisis, a natural question is through which channel—innovation or resource reallocation—this apparent effect was transmitted. We find empirical evidence of an adverse effect of tight credit conditions on R&D, suggesting that the innovation channel contributed to the decline in TFP. The evidence does not point to job reallocation as an important channel.

The innovation channel

The sharp rise in credit risk and tightening in bank lending conditions likely impaired innovation during the financial crisis. Table 2 presents estimation results of regressions of R&D growth on its own first four lags and on credit conditions.[10] As before, the model allows the association of the dependent variable with the measures of credit conditions during the financial crisis to differ from the association during normal times.[11] The regression results in columns 1 through 3 reveal a negative association between credit conditions and R&D growth which is statistically significant for two of the three credit measures—the EBP and bank lending conditions. For those two measures, the estimated relationship becomes more negative during the financial crisis. The shift is statistically significant at the 1 percent level, suggesting fluctuations in credit availability are a less important consideration for R&D in normal times. Therefore, by temporarily dampening R&D growth, the lack of access to credit during the financial crisis may have temporarily restrained TFP growth. Easing credit conditions during the economic recovery provided only a relatively small boost to R&D, leaving the level of R&D persistently lower. Moreover, the estimated coefficients on the lags of R&D growth are significant, reflecting inertia in R&D growth. These results imply that deteriorating credit conditions during the crisis persistently lowered the growth rate of R&D.

Although firms appear to have cut R&D due to a lack of access to credit, they may also have cut R&D spending in response to a perceived lack of demand for their innovations. To address the concern that the

Table 2
Regression Results for R&D Growth

Dependent variable: r&d						
	(1)	(2)	(3)	(4)	(5)	(6)
ebp*df	-1.6343***			-2.9236**		
ebp*dn	-0.5136***			-0.5449**		
ted*df		-0.1548			0.7167	
ted*dn		0.2524			0.0276	
sloos*df			-0.0693***			-0.0737*
sloos*dn			-0.0094**			-0.0126**
spf*df				-1.4944	1.9478***	-0.1543
spf*dn				0.0899	-0.4187*	-0.5120**
r&d(-1)	0.3302**	0.2881***	0.2342**	0.3447***	0.2718***	0.1962*
r&d(-2)	0.1876**	0.2593***	0.2629***	0.1754**	0.2037***	0.2479***
r&d(-3)	-0.2742***	-0.3402***	-0.2925***	-0.2644***	-0.3377***	-0.3239***
r&d(-4)	0.2741***	0.1966**	0.2322**	0.2956***	0.2642***	0.2038**
Sample	1974:Q1–2012:Q4	1986:Q1–2015:Q4	1990:Q2–2015:Q4	1974:Q4–2012:Q4	1986:Q1–2015:Q4	1990:Q2–2015:Q4
Observations	156	120	103	153	120	103
R^2	0.3567	0.2439	0.3387	0.3672	0.3187	0.3705

*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

Notes: Regressions include constant terms for the financial crisis and normal times (not reported). Inference is based on HAC standard errors.

regressions may pick up voluntary declines in R&D due to weak anticipated demand for new and better products, columns 4 through 6 add the median one-year-ahead forecast of real GDP growth from the Survey of Professional Forecasters, denoted *spf*, as an explanatory variable. The estimation results show no clear relationship between such forecasts and R&D spending. More importantly, the relationship between the measures of credit conditions and R&D spending remains qualitatively unchanged.[12]

The cuts in R&D during the financial crisis by credit-starved firms may have affected TFP fairly quickly. While it can take years for basic research to be commercialized and even longer for the benefits of new technologies to spill over to the wider economy, a significant part of R&D pertains to product development. Development spending accounted for an average of 71 percent of private R&D spending from 1953 to 2001, while applied research accounted for another 23 percent

(Congressional Budget Office). Spending on basic research averaged just 5 percent of total private R&D spending over this period. Product and process developments can raise productivity in a short time, since such developments are typically well beyond the idea stage and close to market-ready. Moreover, R&D investment is likely correlated with other intangible investments absorbed in TFP, such that cutbacks in R&D investment could be closely associated with declines in productivity. Corrado and Hulten review the research on intangible investment and conclude that the innovation that powers economic growth does not result from R&D alone but is rather linked to "a complex process of investments in technological expertise, product design, market development, and organizational capability." They estimate these investments account for a significant share of productivity-enhancing, intangible capital accumulation. A tightening of credit conditions may therefore interfere with the entire product development process as tight credit squeezes investment spending broadly defined.

The reallocation channel

If the distress in credit markets and the tightening of bank lending conditions caused resource reallocation to drop during the financial crisis, this factor, too, could have restrained TFP growth temporarily. Indeed, empirical studies such as Foster, Haltiwanger, and Krizan show that such reallocation is closely linked to productivity growth. Did the adverse effects of tight credit conditions on job creation outweigh the positive effects on job destruction, or were the two effects largely offsetting? To answer this question, we consider four measures of resource reallocation in the private sector: the rates of gross job gains and losses and the rates of establishment births and deaths.

The regression results in Table 3 suggest tight credit conditions were associated with lower gross job gains during the financial crisis. The estimated coefficients are significantly different from zero except for the TED spread during the financial crisis. Thus, by reducing job creation, the lack of access to credit may have dampened TFP growth during the crisis. The remaining regression coefficients for credit conditions during normal times and for lagged job gains imply that the rate of gross job gains was pulled in opposite directions after the crisis. On the one hand, the estimated coefficients on credit conditions during normal

Table 3
Regression Results for the Rate of Gross Job Gains

Dependent variable: jobgains			
	(1)	(2)	(3)
ebp*df	-0.2719***		
ebp*dn	-0.1494***		
ted*df		-0.0801	
ted*dn		-0.2661*	
sloos*df			-0.0088***
sloos*dn			-0.0041***
jobgains(-1)	0.2890***	0.3209***	0.2521***
jobgains(-2)	0.3249***	0.3784***	0.3051***
jobgains(-3)	-0.1218	-0.1367	-0.1313
jobgains(-4)	0.4547***	0.4444***	0.5447***
Sample	1993:Q3–2012:Q4	1993:Q3–2015:Q2	1993:Q3–2015:Q2
Observations	78	88	88
R^2	0.9353	0.9324	0.9401

*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

Notes: Regressions include constant terms for the financial crisis and normal times (not reported). Inference is based on HAC standard errors.

times (that is, *ebp*dn*, *ted*dn*, and *sloos*dn*) are significant, indicating the normalization of credit conditions after the crisis had a positive effect on job creation. On the other hand, the estimated coefficients for past job gains are also significant, suggesting the adverse effects of the financial crisis persisted even in the recovery. That gross job gains failed to rebound to pre-recession levels suggests the persistent effects of the financial crisis dominated in its aftermath. Consistently, regressions of the rate of establishment births on its own lags and on credit conditions in and outside the financial crisis yielded similar results (not shown), except that the estimated coefficients on credit conditions during normal times were not significantly different from zero. Thus, the reduced reallocation may have had a persistent adverse effect on the level of TFP.

Job reallocation can be due to the destruction of obsolete jobs as well as the creation of new ones. Table 4 presents regressions of the rate of gross job losses on its own lags and on credit conditions. Each of the credit measures has a positive, statistically significant association with the rate of gross job losses during the financial crisis, indicating the tight

Table 4

Regression Results for the Rate of Gross Job Losses

Dependent variable: joblosses			
	(1)	(2)	(3)
ebp*df	0.2538***		
ebp*dn	0.0579		
ted*df		0.3833***	
ted*dn		0.2565**	
sloos*df			0.0132***
sloos*dn			0.0005
joblosses(-1)	0.8477***	0.8643***	0.8503***
joblosses(-2)	0.0366	0.0127	0.0383
joblosses(-3)	-0.0836	-0.0697	-0.0772
joblosses(-4)	0.1501	0.1377	0.1514
Sample	1993:Q3–2012:Q4	1993:Q3–2015:Q2	1993:Q3–2015:Q2
Observations	78	88	88
R^2	0.8675	0.9129	0.9118

*** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level
Notes: Regressions include constant terms for the financial crisis and normal times (not reported). Inference is based on HAC standard errors.

credit conditions contributed to the surge in job losses during the recession. While job losses characterize a major cost of recessions for workers, research on productivity associates higher reallocation with higher productivity growth. When the least productive jobs are destroyed, the economy becomes more productive, and workers are freed up to ultimately move into more productive jobs. Thus, by encouraging the destruction of unproductive jobs, the tight credit supply may have boosted TFP growth during the financial crisis.[13] Moreover, the estimated coefficients on lagged job losses suggest the effect of the crisis on job losses may have lingered in the crisis's aftermath. However, the regression on the TED spread also yields a significant coefficient during normal times, suggesting the normalization of credit conditions may have contributed to the decline in job losses after the crisis by allowing less productive jobs to once again survive. Regressions of the rate of establishment deaths on its own lags and on credit conditions during the financial crisis and during normal times yielded similar results (not shown).

Table 5
Regression Results for the Rate of Job Reallocation

Dependent variable: jobrlc			
	(1)	(2)	(3)
ebp*df	0.1523**		
ebp*dn	-0.1326		
ted*df		0.2283***	
ted*dn		0.0796	
sloos*df			0.0081***
sloos*dn			-0.0034
jobrlc(-1)	0.3745***	0.3924***	0.3599***
jobrlc(-2)	0.2570***	0.2803***	0.2807***
jobrlc(-3)	-0.1224	-0.1843*	-0.1435
jobrlc(-4)	0.5427***	0.5212***	0.5389***
Sample	1993:Q3–2012:Q4	1993:Q3–2015:Q2	1993:Q3–2015:Q2
Observations	78	88	88
R^2	0.9602	0.9663	0.9683

*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

Notes: Regressions include constant terms for the financial crisis and normal times (not reported). Inference is based on HAC standard errors.

As tightening credit conditions pulled job gains and job losses in opposite directions, the net effect of credit conditions on job reallocation was likely small during the financial crisis. Table 5 presents estimation results for the rate of job reallocation. The estimated coefficient on credit conditions is positive and significant during the financial crisis, suggesting tightening credit availability raised job reallocation. In other words, the positive effect of the credit squeeze on the rate of gross job losses may have outweighed its negative effect on the rate of gross job gains; however, the net effect is likely small, since the rate of job reallocation only ticked up slightly during the crisis. Moreover, the estimation result is not robust using the rate of establishment reallocation, which yields a significant estimated coefficient on only one of the three measures of credit conditions. Taken together, the evidence suggests the financial crisis had largely offsetting effects on resource reallocation; reduced innovation thus seems a more likely explanation for the link between credit conditions and TFP growth.

IV. Conclusion

A decline in TFP contributed to a persistent drop in output during the financial crisis and recession of 2007–09. To unpack the sources of these declines, this article investigates the effects of the distress in credit markets and the tightening of bank lending conditions on total factor productivity during the financial crisis and recession. The analysis suggests productivity declined persistently as a result of the crisis. We find empirical evidence suggesting a lack of access to credit likely curtailed R&D, one channel through which financial stress can affect productivity. However, we find little empirical evidence of a reduction in resource reallocation, another channel through which credit conditions can affect productivity.

Our analysis does not explain the slow pace of productivity growth since the crisis, which has been a source of great concern among economists and policymakers. From 2010 to 2014, TFP growth averaged just 0.6 percent per year, well below its average growth rate of 1 percent from 1970 to 2010. If the slowdown persists, it may affect future standards of living. However, while the financial crisis seems to have persistently reduced the level of TFP, we have not found persistent effects on the growth rate of TFP.

Endnotes

[1]A few of these studies examine the role of labor and capital inputs for the persistent decline in output (Blanchard, Cerutti, and Summers; Hall; Reifschneider, Wascher, and Wilcox).

[2]Eichengreen, Park, and Shin find that a higher TED spread is associated with the incidence of TFP slumps prior to the global financial crisis in a sample of advanced economies.

[3] The start date and end date of the financial crisis are assumed to coincide with the peak and trough of the recession, as determined by the National Bureau of Economic Research, to facilitate comparisons with previous business cycles. The onset of the financial crisis is often traced back a quarter earlier, to August 2007, when the French bank BNP Paribas suspended redemptions from three of its investment funds (see, for example, Bernanke).

[4]Davig and Hakkio perform an empirical analysis of the relationship between financial stress and broad economic activity and find that financial stress has a stronger effect on economic activity when the economy is in a distressed state.

[5]Bils, Chang, and Kim provide a rigorous framework in which paid work and unobserved effort do not move in tandem. Their search and matching model predicts a decline in employment and a rise in worker effort in recessions when wages are slow to adjust.

[6] The rates of gross job gains and losses have been trending down since well before the last recession, as noted by others (see, for example, Davis and Haltiwanger). Clearly, this secular decline is unrelated to the financial crisis.

[7]More broadly, Ng and Wright survey business cycle facts, emphasizing the last recession, and document how recessions with financial market origins are distinct from those in which financial markets play a passive role.

[8]Distinguishing between expansions and recessions prior to the last one did not affect the qualitative results regarding the association of TFP growth with credit conditions and factor utilization during the financial crisis.

[9]We perform a Durbin-Wu-Hausman test for regressor endogeneity to address the concern that ordinary least squares may yield inconsistent estimates if some of the right-hand-side variables are endogenous. Specifically, the test uses two-stage least squares with the first eight lags of the 10-year Treasury yield as instruments. The null hypothesis that x and u are exogenous cannot be rejected for any of the combinations of measures of x and u (we obtain similar results using the first four lags of x and u as instruments instead). Because estimation by ordinary least squares yields more efficient estimators than instrumental variables estimation, we adopt the former method.

[10]R&D growth is measured by the quarterly growth rate of real private fixed investment in research and development (NIPA Table 5.3.3). Using the growth rate of total real research and development (NIPA Table 1.2.3) as an alternative

measure of R&D yields qualitatively similar regression results, though the drop in the growth rate from a year earlier during the recession is less dramatic.

[11]We estimate the models in Tables 2–5 using ordinary least squares. The regressor endogeneity test using lags of the 10-year Treasury yield as instruments cannot reject the null hypothesis of exogeneity of the measures of credit conditions for any of the regressions.

[12] In the same spirit, we also add four lags of GDP growth in the regressions reported in Tables 2–5 to account for aggregate demand effects on the variable of interest. This addition has only a minor effect on the magnitude and significance of the estimated coefficients on credit conditions.

[13]Petrosky-Nadeau highlights a related effect of credit conditions on resource reallocation: as reduced access to credit has a more adverse influence on less productive firms, the financial crisis may have raised aggregate productivity by shifting the mix of firms toward more productive ones.

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