NEW EVIDENCE ON THE IMPACT OF FINANCIAL CRISSES
IN ADVANCED COUNTRIES

APPENDIX C
Robustness of the Estimates of the Effect of Financial Distress on Output

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This appendix discusses numerous robustness checks of our baseline estimates of the effect of financial distress on output. All of the alternatives described use our new measure of financial distress as the explanatory variable. We discuss the results using both industrial production and real GDP as the output variable. However, for simplicity, the graphs only show the results for real GDP. Each graph also repeats the baseline results for GDP from Figure 3b of the paper.

A. Alternative Specifications

We consider several variations of our baseline specification.

**Single-Equation Model.** The first is to replace the Jordà approach with a single-equation autoregressive specification. In particular, we estimate an equation of the form:

\[
\Delta y_{j,t} = \alpha_j + \gamma_t + \sum_{k=0}^{6} \phi_k F_{j,t-k} + \sum_{k=1}^{6} \theta_k \Delta y_{j,t-k} + e_{j,t},
\]

where the output variable (either industrial production or real GDP) is now expressed as the change in logarithms. We include the contemporaneous value and six lags of the crisis variable and six lags of the change in the output variable. We then simulate the impact of a realization of the distress variable equal to 7 (a moderate crisis–minus on our scale). This specification does not provide any information about the evolution of the crisis variable, but the simulation requires an assumption about the values of the variable after the initial realization. There are two natural baseline cases: a one-period crisis \((F_{j,t} = 7\) with \(F_{j,t+k} = 0\) for \(k > 0\)), and a permanent
crisis \( (F_{t+k} = 7 \text{ for all } k \geq 0) \). Since most crises are relatively short, we focus on the temporary case.

Figure C1 shows the results using GDP as the output variable. The contemporaneous effect of a crisis is a fall in GDP of 2.9 percent \( (t = -5.9) \), which is very similar to the baseline result. However, the results of the single-equation model for GDP are substantially different from the baseline at longer horizons. Even in the full sample, the effects of a crisis are quite temporary. In response to a one-time realization equal to 7 on our scale, real GDP is down only 1.0 percent after six months, and 0.2 percent after a year. The effects fluctuate somewhat at longer horizons, but they are small (around 1 percent) and at most marginally significant. For industrial production, the contemporaneous effect of a crisis is a fall of 3.5 percent \( (t = -4.2) \), again very similar to the baseline result. The results for industrial production are similar to those of the baseline even at longer horizons; in both specifications, the effects are quite short-lived—disappearing entirely within two years.

**Vector Autoregressions**. A sensible way to improve this autoregressive specification and bring it closer to the Jordà approach is to run vector autoregressions (VARs). Adding a second equation for the financial distress variable allows the data to determine how the distress variable evolves following an innovation. The two equations then jointly imply how output and financial distress respond to an innovation in distress. As a result, the impulse response functions are analogous to those from the Jordà approach, but with the responses at all horizons computed from the two equations rather than estimated separately at each horizon.

Specifically, we consider VARs with two variables, output (either industrial production or GDP), entered in log levels, and our new distress measure. Paralleling the timing assumption in our baseline specification, we order the distress variable first. The VARs include six lags. Figure C2 shows the impulse response function of real GDP to an impulse in distress of 7. The VAR estimates are extremely similar to those in our baseline specification in size, timing, and precision. This is equally true when industrial production is used as the output variable. One
minor difference in both cases is that the longer-run impact of financial distress is slightly more negative under the VAR specification than in the baseline.

**A Nonparametric Approach to Nonlinearities.** In the paper, we examine the possibility that the effects of distress are not linear in our distress measure, $F$, by allowing the effects of distress to take the form $f(F)$ and including a quadratic term in $f(\cdot)$: $f(F) = F + bF^2$.

A less parametric approach is to allow $f(\cdot)$ to take on a different value for different types of crises. In particular, we consider the specification,

\[(C2) \quad f(F_{j,t}) = \sum_{m=1}^{4} \lambda_mD_{j,t}^m,\]

where $D_{j,t}^1$ is a dummy variable for credit disruptions (that is, for $F_{j,t}$ equal to 1, 2, or 3), $D_{j,t}^2$ is a dummy variable for minor crises ($F_{j,t}$ equal to 4, 5, or 6), $D_{j,t}^3$ is a dummy variable for moderate crises ($F_{j,t}$ equal to 7, 8, or 9), and $D_{j,t}^4$ is a dummy variable for major and extreme crises ($F_{j,t}$ equal to 10 or more). With this specification, the $\lambda$'s capture the severity of the different categories of crises.

We substitute this expression for $f(\cdot)$ into equation (3) of the paper. In order for the $\phi$'s and $\lambda$'s to be separately identified, we need some normalization. The one we choose is to set $\lambda$ for credit disruptions to the mean value of financial distress conditional on there being a credit disruption, which is 2.2. That is, we normalize $\lambda_1$ to 2.2.

When GDP is used as the output measure, the resulting estimates of the remaining $\lambda$'s (with standard errors in parentheses) are $\hat{\lambda}_2 = 2.61 (0.68)$, $\hat{\lambda}_3 = 6.60 (1.54)$, and $\hat{\lambda}_4 = 9.06 (2.62)$. For comparison, in the baseline specification, where $f(F) = F$, the mean of $f(F)$ conditional on $F$ being in a given category is 4.93 for category 2 (that is, for $F$ equal to 4, 5, or 6); 8.00 for category 3 ($F$ equal to 7, 8, or 9); and 12.00 for category 4 ($F$ equal to 10 or more). Thus—consistent with the results from the quadratic specification—the estimates from this specification suggest only moderate nonlinearity, and the point estimates are in the direction of
the effects of distress rising less than linearly with $F$.

When industrial production is used as the output measure, the estimates are $\hat{\lambda}_2 = 1.99 (0.79)$, $\hat{\lambda}_3 = 6.30 (1.93)$, and $\hat{\lambda}_4 = 16.38 (5.26)$. Thus, in this case the estimates indicate relatively modest effects of minor crises, and large (but imprecisely estimated) effects of high levels of distress.

**Adding Country-Specific Trends.** We also consider a permutation of the baseline specification that keeps the basic Jordà approach, but adds country-specific trends. This allows for different trends across countries in their growth rates. The results from this specification using GDP as the output variable are shown in Figure C3. The estimated impulse response is similar to that of the baseline specification, though slightly less negative at longer horizons. The estimates using industrial production are very similar to the baseline under this alternative specification.

**B. Shorter Time Period**

Another way to deal with the fact that countries may have different trends in their normal growth is to consider a shorter time period. Since our new measure shows almost no cases of financial distress in the first two decades covered by our chronology, the natural shorter time period is 1987:1–2007:1. In considering this alternative time period, we return to the baseline specification given by equation (1) in the paper.

Figure C4 shows the impulse response function estimated for this shorter time period using GDP as the output variable. This change has very little impact on the near-term effects of a financial crisis. However, it has more impact on the estimated longer-run effects. For example, the effect of a crisis on GDP after 10 half-years is $-3.6 (t = -1.9)$ in the baseline’s full time period, but just $-0.5 (t = -0.4)$ in the shorter time period. The results for the impulse response function of industrial production to distress change in much the same way: the near-term effects are largely unchanged and the longer-run effects show even less persistence than in
the baseline. Indeed, the results for the shorter time period show moderately positive (but insignificant) longer-term effects of distress on industrial production.

C. **Alternative Sample of Countries**

As we discuss in the paper, Japan is an important outlier in terms of the persistence of its financial distress. For this reason, the paper considers how the estimated impulse response functions for GDP and industrial production change when Japan is excluded from the sample of OECD countries. Excluding Japan results in estimates of the impulse response function that are slightly smaller in the near-term and dramatically less persistent over the longer term—particularly when real GDP is used as the output measure. It is useful, however, to consider the importance of outliers more generally.

**Partial Associations.** The obvious way to identify influential observations is to examine the partial association between output at various horizons and distress at time \( t \) corresponding to the baseline impulse responses derived from equation (1) in the paper. In forming the partial association, we use real GDP as the output measure. The sample period is 1969:1 to 2007:1 as before, and we include the full sample of 24 OECD countries.

Panel (a) of Figure C5 plots the partial association at horizon 0. That is, it shows the scatter of points that determines the contemporaneous element of the baseline impulse response function. Perhaps the most important characteristic of the figure is that there are a mass of points lying along a gently downward-sloping line. This suggests that the relatively modest effect of financial distress on output that we find at horizon 0 reflects a fairly general phenomenon, rather than the impact of a few episodes. The figure labels the most extreme observations. Turkey in 2001:1 stands out as an observation tending to magnify the contemporaneous effects of financial distress on GDP. Norway in 1991:2 appears to be a powerful observation going in the direction of minimizing the impact of distress.

Panel (b) of Figure C5 reports the partial association after 2½ years—that is, between
output at $t+5$ and distress at $t$. Thus, it shows the scatter of points that determines the value of the $i = 5$ element of the impulse response function derived from equation (1). This panel shows a noticeably less tight relationship. It also shows an interesting pattern. Turkey in 2001:1 is again a moderate outlier going in the direction of implying a negative impact of financial distress. But, by far the much bigger outlier is Japan. Five of the most extreme observations of positive crisis residuals and negative GDP residuals at this horizon are for Japan in the 1990s. This is consistent with the finding discussed earlier that excluding Japan has a large impact on the estimated impulse response function of GDP to the new financial distress variable, particularly at longer horizons. As with the contemporaneous partial association, Norway in 1991:2 is the most obvious observation that may be lessening the impact of financial distress at this longer horizon.

**Sample Excluding Turkey.** Because Turkey appears to be an influential observation, we examine the impact of excluding it from the sample of countries. The effects of this change are shown in Figure C6, which plots the impulse response function of real GDP to distress estimated for the sample of countries excluding Turkey (run over the full time period). The main effect is to lower the estimated contemporaneous impact of financial distress by about one-third. The estimated effects after one to three years are little changed, and the estimated effects at longer horizons are slightly more negative than in the baseline sample. When industrial production is used as the output variable, the impact of excluding Turkey is similar: the contemporaneous impact is reduced by about one-third, and the longer-term responses are now very slightly negative rather than very slightly positive.

**Sample Excluding Norway.** The partial associations suggest that Norway may be an influential observation tending to reduce the impact of financial distress on GDP. For this reason, we also examine the impact of excluding it from the sample of countries. The effects of this change are shown in Figure C7, which plots the impulse response function of real GDP to distress estimated for the sample of countries excluding Norway (run over the full time period).
This change has only a small impact on the contemporaneous response of GDP to an impulse in our distress measure of 7 (changing it from −3.02 to −3.39). It has a somewhat greater impact at longer horizons, where the estimated negative responses increase by about 30 percent. When industrial production is used as the output variable, the impact of excluding Norway is somewhat larger at near horizons than it is for GDP, but the impact is modest in absolute terms at longer horizons.

D. Standard Errors

In our baseline results in the paper, we report conventional OLS standard errors. However, there are two reasons that the residuals might not be i.i.d. First, they may be heteroskedastic. For example, output is typically more volatile in the less developed countries of our sample, such as Greece and Turkey, and in the smaller countries, such as Luxembourg, Iceland, and New Zealand. Second, for horizons beyond one half-year, there is an overlapping structure to the residuals. For the case of \( i = 10 \), for example, the dependent variable for observation \( t \) for a country is in essence its growth from \( t - 1 \) to \( t + 10 \), and for observation \( t + 1 \) it is growth from \( t \) to \( t + 11 \). This pattern could lead to serial correlation of the residuals.

We therefore consider three alternatives to OLS standard errors. The first is heteroskedasticity-consistent standard errors. The other two allow for serial correlation as well as heteroskedasticity. Specifically, for horizons \( i = 1 \) to 10, we allow for serial correlation over up to \( i \) periods; for example, for \( i = 1 \), we allow for first-order serial correlation of the residuals. We consider both Newey-West standard errors (which damp the off-diagonal elements of the covariance matrix of the residuals) and Hansen-Hodrick standard errors (which have no damping).

Table C1 reports the baseline point estimates and OLS standard errors for the response of real GDP to financial distress, along with the three alternative series of standard errors. Panel (a) shows the results for the full sample of countries; panel (b) shows the results for the sample
excluding Japan. Considering the alternative standard errors has little impact on the overall pattern of the results. The three alternative sets of standard errors are generally very similar to one another. For horizons of a year and longer, the alternatives are typically about 20 percent larger than the OLS standard errors when we use the full sample, and about 30 percent smaller when we use the no-Japan sample. The only large differences between the alternative and OLS standard errors are at very short horizons. For these horizons, the alternative standard errors are almost twice as large as the OLS ones.\(^1\) As a result, the near-term relationship between financial distress and GDP becomes less statistically significant. For example, the \(t\)-statistic for the contemporaneous relationship falls from −6.1 to −3.5 for the full sample and from −5.2 to −2.6 for the no-Japan sample.\(^2\)

When industrial production is used as the output variable, the alternative standard errors are again quite similar to one another. At longer horizons the alternative standard errors are typically about 30 percent larger than the conventional OLS standard errors for the full sample and about 25 percent smaller for the no-Japan sample. But, at near horizons, the alternative standard errors in the industrial production regressions are only about 40 percent larger than the OLS standard errors in both samples. As a result, the \(t\)-statistic for the contemporaneous relationship falls from −4.2 to −3.3 for the full sample and from −2.5 to −1.8 for the no-Japan sample.

**E. Conclusions**

The results of the various robustness checks analyzed in this appendix suggest that the baseline estimates of the impact of financial distress on output are quite durable. Indeed, the

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\(^1\) The differences at short horizons come entirely from the observations for Turkey. As mentioned above, Turkey in 2001 stands out as having a large spike in distress and an exceptionally large fall in output. When Turkey is omitted from the sample, the alternative standard errors at short horizons are actually slightly smaller than the OLS ones.

\(^2\) We have also experimented with clustering either by time period or by country. Clustering by time period produces standard errors very similar to the heteroskedasticity-consistent ones. Clustering by country (which should be interpreted with caution, since there are only 24 clusters in this case) yields standard errors about 10 percent larger than the other alternative standard errors for horizons up through a year and a half, and about 20 percent larger at longer horizons.
permutation that affects the estimates the most is that discussed in the paper—excluding Japan from the sample of countries.

Given that our key finding is that the effects of a financial crisis on output appear to be quite modest, perhaps the most important feature of the robustness checks is that none of them suggests that the negative effects are large. A few, such as excluding Norway from the sample, increase the negative effects somewhat. But most of the alternative specifications, time periods, and samples of countries considered lower rather than increase the estimated negative effects—some of them, such as excluding Japan, quite substantially. As a result, it is highly unlikely that our finding is being driven by the particulars of our empirical approach.
Figure C1  
Impulse Response Function, Real GDP to Financial Distress, Full Sample  
Single-Equation Model

Notes: The blue lines in the figure show the baseline estimates discussed in the paper (solid line), along with the two-standard-error confidence bands (dashed lines). The solid red line shows the impulse response function for real GDP to a one-period impulse of 7 in our new measure of financial distress derived from estimating equation (C1) for the full sample of 24 OECD countries. The red dashed lines show the two-standard-error confidence bands for the single-equation specification.
FIGURE C2
Impulse Response Function, Real GDP to Financial Distress, Full Sample
Vector Autoregression

Notes: The blue lines in the figure show the baseline estimates discussed in the paper (solid line), along with the two-standard-error confidence bands (dashed lines). The solid red line shows the impulse response function for real GDP to an impulse of 7 in our new measure of financial distress derived from a two-equation VAR estimated for the full sample of 24 OECD countries. See appendix text for more details of the VAR specification. The red dashed lines show the two-standard-error confidence bands for the VAR specification.
**FIGURE C3**

Impulse Response Function, Real GDP to Financial Distress, Full Sample
Jordà Approach, Including Country-Specific Trends

Notes: The blue lines in the figure show the baseline estimates discussed in the paper (solid line), along with the two-standard-error confidence bands (dashed lines). The solid red line shows the impulse response function for real GDP to an impulse of 7 in our new measure of financial distress derived from estimating a variant of equation (1) from the paper that includes a trend for each country. As in the baseline, the alternative is estimated using the full sample of 24 OECD countries. The red dashed lines show the two-standard-error confidence bands for the specification including country-specific trends.
Notes: The blue lines in the figure show the baseline estimates discussed in the paper (solid line), along with the two-standard-error confidence bands (dashed lines). The solid red line shows the impulse response function for real GDP to an impulse of 7 in our new measure of financial distress derived from estimating equation (1) from the paper for the full sample of 24 OECD countries, but using the shorter time period 1987:1 to 2007:1. The red dashed lines show the two-standard-error confidence bands for the shorter-time-period estimation.
Figure C5
Partial Association of Real GDP and Financial Distress

a. Contemporaneous

b. Five Half-Years After

Notes: The figures show the partial association between real GDP at horizons \( t \) and \( t+5 \), respectively, and financial distress at \( t \) derived from estimating equation (1) from the paper for the full sample of 24 OECD countries.
**FIGURE C6**
Impulse Response Function, Real GDP to Financial Distress, Jordà Approach
Sample Excluding Turkey

Notes: The blue lines in the figure show the baseline estimates discussed in the paper (solid line), along with the two-standard-error confidence bands (dashed lines). The solid red line shows the impulse response function for real GDP to an impulse of 7 in our new measure of financial distress derived from estimating equation (1) from the paper for the sample of OECD countries excluding Turkey (estimated over the full time period). The red dashed lines show the two-standard-error confidence bands for the sample excluding Turkey.
Notes: The blue lines in the figure show the baseline estimates discussed in the paper (solid line), along with the two-standard-error confidence bands (dashed lines). The solid red line shows the impulse response function for real GDP to an impulse of 7 in our new measure of financial distress derived from estimating equation (1) from the paper for the sample of OECD countries excluding Norway (estimated over the full time period). The red dashed lines show the two-standard-error confidence bands for the sample excluding Norway.
## Table C1
Baseline Impulse Response Function of Real GDP to Financial Distress
Alternative Standard Errors

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Notes: The point estimates and the OLS standard errors are for the baseline specification of the relationship between real GDP on financial distress. See text of paper for details. Panel (a) is for the full sample of 24 OECD countries; panel (b) is for the sample of countries excluding Japan. The right three columns show alternative estimates of the standard errors. See appendix text for details.