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1984 | January 2015

Web: www.ifw-kiel.de

Kiel Working Paper 1984 | January 2015

A Note on Banking and Housing Crises and the Strength of Recoveries*

Jens Boysen-Hogrefe, Nils Jannsen and Carsten-Patrick Meier

Abstract:
We investigate whether recoveries following normal recessions differ from recoveries following recessions that are associated with either banking crises or housing crises. Using a parametric panel framework that allows for a bounce-back in the level of output during the recovery, we find that normal recessions are followed by strong recoveries in advanced economies. This bounce-back is absent following recessions associated with banking crises and housing crises. Consequently, the permanent output losses of recessions associated with banking crises and housing crises are considerably larger than those of normal recessions.

Keywords: Business cycle; recovery; banking crisis; housing crisis

JEL classification: E32, C33

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*We would like to thank Jonas Dovern, Margitta Führmann, Paul Kramer, Harmen Lehment, Maik Wolters, and Vera Zipperer for very helpful comments and suggestions. An earlier version of this paper was circulated under the title “The Ugly and the Bad: Banking and Housing Crises Strangle Output Permanently, Ordinary Recessions Do Not”.

1 Introduction

We investigate the strength of recoveries following recessions. Therefore, we differentiate between recessions associated with severe crises, i.e., banking crises or housing crises, and recessions that are not associated with banking crises or housing crises (normal recessions). Our approach in differentiating between these types of recessions is motivated by the competing findings in the literature.

Several studies on recessions associated with banking or other financial crises find that such recessions are particularly long-lasting and severe and that the subsequent recoveries are weak. This finding has already been documented, for example, by Kaminsky and Reinhart (1999) and Bordo et al. (2001), and affirmed by studies such as Reinhart and Rogoff (2008, 2009a, 2009b), Cecchetti et al. (2009), and Haugh et al. (2009). Moreover, many studies find that recessions associated with banking crises dampen the level of output permanently (Boyd et al., 2005; Cerra and Saxena, 2008; Furceri and Mourougane, 2009; IMF, 2009b). This view is challenged by Bordo and Haubrich (2012) and Howard et al. (2011). Bordo and Haubrich analyze 27 business cycles in the United States starting in 1882 and find that recoveries after banking crises do not differ from other recoveries. Howard et al. perform a similar analysis for 59 advanced and emerging market economies over the past 40 years and come to a similar conclusion. However, Bordo and Haubrich relate slow recoveries to weak dynamics of residential investment. In an event study, Howard et al. find that recessions with large declines in house prices tend to be followed by slow recoveries. This finding underlines that housing crises have been proven to have severe economic consequences (Claessens et al., 2009; Jannsen, 2010; Aßmann et al. 2013).

The strength of recoveries and the permanent effects of recessions on levels of output were already analyzed using time series models in the 1980s and 1990s. Nelson and Plosser (1982), Campbell and Mankiw (1987), and Hamilton (1989) find that recessions have large permanent effects on output. Beaudry and Koop (1993) find, once they allow for nonlinear effects in their empirical model, that recessions in the United States are followed by a bounce-back in the level of output—or alternatively by particularly strong recoveries—and consequently that recessions have only small or even no permanent effects on the level of output. Sichel (1994) and Kim et al. (2005), among others, confirm this finding. While there

is strong evidence for this finding in the United States, the evidence for other economies is mixed. Balke and Wynne (1996) find evidence for strong recoveries following recessions for the G-7 economies as an aggregate. However, Bradley and Jansen (1997), who apply the approach of Beaudry and Koop (1993) to the G-7 countries, find evidence for strong recoveries only for the United States, Italy, and to a lesser degree Germany. Kim et al. (2005) find the bounce-back effect to be much smaller for several other advanced economies than for the United States.

A major contribution of our study is that we combine the time series literature on strength of recoveries with the literature on the effects of banking crises and housing crises. In particular, we explicitly evaluate the strength of recoveries following recessions associated with severe crises compared to normal recessions that are not associated with such crises using the time series model presented in Beaudry and Koop (1993). We explicitly differentiate between normal recessions, recessions associated with (simultaneous) banking crises and housing crises, and recessions associated with pure housing crises (but not with banking crises).[1] Our results on the strength of recoveries also provide information about the permanent effects of normal recessions on the level of output compared to recessions associated with severe economic crises.[2]

Using a panel data set for 17 advanced economies between 1970 and 2012, we find that normal recessions and recessions associated with banking and housing crises differ sharply in terms of the subsequent recovery. While normal recessions are followed by a bounce-back effect in the level of output, this bounce-back effect is absent after recessions associated with banking and housing crises. Moreover, the bounce-back effect is considerably weaker in recoveries following recessions associated with pure housing crises than in recoveries following normal recessions. Our results indicate that the permanent effects of recessions on the level of output do not only depend on the depth and the length of a recession. Even if

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[1] We do not differentiate the recessions associated with pure banking crises (but not with housing crises) due to a lack of observations. See Section 3 for a detailed data description.

[2] In this regard our results are also relevant for the extensive literature that tests for unit-roots in GDP. The results of unit root tests might be, however, difficult to interprete in the presence of large output fluctuations, which can be usually observed during severe crises, see, e.g., Kilian and Ohanian (2002).

recessions were identical in terms of their depth and their length, our results suggest that the permanent effects of recessions associated with banking and housing crises or with pure housing crises would be much larger than those of normal recessions because the recovery is significantly stronger after normal recessions.

While our results are in line with the earlier literature about the overall effects of banking crises, they are not in line with the results of Bordo and Haubrich (2012) or Howard et al. (2011) who both analyze explicitly the strength of recoveries. In addition to the different methodology we use, one reason for the different results might be that we investigate the effects of banking crises and housing crises on the strength of recoveries in a joint framework. Overall, by differentiating between recoveries following normal recessions and following recessions associated with severe economic crises, we are able to explain some of the heterogeneity in the results of the literature on the strength of recoveries. We use a series of tests to show that our main results are robust with respect to several modifications of our baseline specifications. In particular, our results are robust when we do not include the recessions and the banking and housing crises of the years 2008 and 2009 and the subsequent recoveries in our sample.

The structure of the remaining paper is as follows. Section 2 presents our estimation methodology. Section 3 describes the data set. Section 4 presents our estimation results and illustrates them graphically. Section 5 summarizes the results and concludes.

2 Methodology

We use a panel framework to estimate the effects of banking and housing crises on the strength of recoveries because such crises are rare events. To account for nonlinear dynamics following recessions—independently whether they are normal or associated with severe crises—we augment an autoregressive panel model of GDP growth by the current-depth of

recessions (*cdr*) term introduced by Beaudry and Koop (1993).[3] The *cdr* term is defined as the deviation of current GDP from its previous peak:

$$cdr_t = \max(y_{t-j})_{j\geq 0} - y_t, \quad (1)$$

where $\max(y_{t-j})_{j\geq 0}$ refers to the peak of log real GDP until year *t*. When real GDP falls below its previous peak (or alternatively when real GDP growth is negative), the *cdr* term becomes positive; otherwise, the term is equal to zero. Therefore, during recessions, cdr_t becomes positive until GDP reaches its previous peak again. During expansions, cdr_t is equal to zero.

By using the *cdr* term, we deviate from the literature on the effects of severe crises (Cerra and Saxena, 2008) and on the strength of recoveries (Cerra and Saxena, 2005), which uses dummy variables to account for phases of severe crises or recoveries. In contrast to most of the literature on severe crises, we focus exclusively on the recovery phase and do not estimate the average depth of severe crises in terms of GDP by using dummy variables, but interpret severe crises as shocks that can have very different sizes. In this regard, the approach of Beaudry and Koop (1993) is more flexible than using dummy variables because it relates the strength of a recovery to the depth of the preceding recession. The autoregressive panel model that is augmented by the *cdr* term is given by

$$\Phi(L)\Delta y_{t,i} = \alpha_i + [\Omega(L) - 1]cdr_{t,i} + \varepsilon_{t,i}, \quad (2)$$

where Δy_t is real GDP growth in country *i* year *t*, the lag polynomial of Φ denotes the autoregressive structure of GDP growth, and α_i denotes country fixed effects. The lag polynomial of Ω measures the impact of the *cdr* term on GDP growth. If the sum of all coefficients is positive, economic growth will on average be stronger during recoveries when the *cdr* term is positive than during expansions when the *cdr* term is zero. Moreover, positive

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[3] For an overview and a detailed description of nonlinear methods used in empirical macroeconomics, see Granger (2001).

coefficients for the *cdr* term indicate a significant bounce-back effect in the level of GDP as deeper recessions are associated with stronger subsequent economic growth.

To assess the impact of banking crises and housing crises on recoveries, we define interaction terms between dummy variables that indicate whether a recession was associated with a banking and a housing crisis and the *cdr* term. We differentiate between recessions that are associated with banking crises and housing crises, and recessions that are associated with pure housing crises. Due to data limitations, we do not include an interaction term for recessions that are associated with pure banking crises in our model.[4] The interaction terms are given by $cdr_{t,i}^{bc,hc}$ (when a recession was associated with a banking crisis and a housing crisis) and $cdr_{t,i}^{hc}$ (pure housing crisis). They are equal to the value of the *cdr* term if a recession was associated with these crises and are zero otherwise. We estimate the effects of severe crises by including the interaction terms, $cdr_{t,i}^{bc,hc}$ and $cdr_{t,i}^{hc}$, in equation (2)

$$\Phi(L)\Delta y_{t,i} = \alpha_i + [\Omega(L)-1]cdr_{t,i} + [\Gamma(L)-1]cdr_{t,i}^{bc,hc} + [\Pi(L)-1]cdr_{t,i}^{hc} + \varepsilon_{t,i}, \quad (3)$$

where the lag polynomials of Γ and Π measure the impact of severe crises on the strength of the recovery. Negative coefficients for the interaction terms indicate that recoveries following recessions that are associated with severe crises are weaker.

3 Data

We use a panel data set of 17 advanced economies.[5] We focus, following Claessens et al. (2009), and IMF (2009a), exclusively on advanced economies because data on house prices are available in a consistent database only for such economies. Moreover, focusing exclusively on advanced economies ensures that we use a relatively homogeneous data set for our empirical analysis and are not mixing data from economies with sharply differing market

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[4] See Section 3 for a detailed data description.

[5] These economies are Australia, Belgium, Canada, Denmark, Finland, France, Germany, Great Britain, Italy, Ireland, Japan, the Netherlands, Norway, Spain, Sweden, Switzerland, and the United States.

structures, institutions, or risk perceptions. The analysis is based on annual data from 1970 to 2012, and we use real GDP as taken from national sources as measure for economic activity.

In the literature, housing crises are usually identified by real house price developments and are characterized by periods of falling prices (Ahearne et al., 2005; Cunningham and Kolet 2011; Jannsen, 2010; IMF, 2003; Claessens et al., 2009). Building on Ahearne et al. (2005), Jannsen (2010), and Claessens et al. (2009), we define a housing crisis as a period following a house price peak. We identify a house price peak as a centered nine-year high in real house prices. Thus, according to our identification criterion, there has to be a minimum period of five years between two consecutive housing crises.[6] The starting year of the crisis is defined as the year when real house prices peak.[7] Data on real house prices are from the International House Price Database of the Federal Reserve Bank of Dallas, which start in 1975. We use real house price data from the Bank of International Settlements to extend the data set for real house prices until 1970. With respect to banking crises, we rely on the chronology of banking crises provided in Laeven and Valencia (2010). Throughout this paper, we define a recession as a period of negative GDP growth, which is common in the literature when using a data set of advanced economies and annual data. According to this criterion, we have 60 recessions in our sample. In addition, we have 43 housing crises and 18 banking crises in our sample.

As we are interested in the existence and the strength of bounce-back effects following both normal recessions and recessions associated with severe crises, we differentiate between these two types of recessions. We consider a recession to be associated with a banking crisis or a housing crisis if it begins within a period of two years after the crisis began. It turns out that 15 out of the 18 banking crises and 32 out of the 43 housing crises are associated with a recession. Furthermore, 10 recessions are associated with banking crises and housing crises. Consequently, we have 5 recessions that are associated with pure banking crises, 22 reces-

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[6] Our results are robust with respect to the length of the moving window, for which we require a centered high of real house prices, and with respect to requiring a minimum decline of real house prices in the period following a house price peak. In the online appendix, we provide robustness checks of our results when using various dating schemes for housing crises.

[7] As an example, we identify the year 2006 as a starting year of a housing crisis in the United States because the level of house prices peaked in 2006 (house prices started to decline in the year 2007) and reached a local maximum in the period from 2002 to 2010.

sions that are associated with pure housing crises, and 23 normal recessions. Given the small number of pure banking crises, we do not include them in our baseline model.[8]

4 Results

We use an AR(2) process as our baseline model. Preliminary tests show that the first two lags in GDP growth are significant in most specifications, while higher lags are usually not. We start by estimating the models (2) and (3) using panel fixed effects.

In the first specification, we do not differentiate between normal recessions and recessions associated with banking or housing crises and estimate model (2) by allowing for one lag of the *cdr* term. We find only a slightly positive parameter value that is, however, significantly different from zero (Table 1, specification I). The coefficient estimate of 0.20 for the term $cdr_{t-1,i}$ indicates that for every 1% that GDP falls below its previous peak during a recession, the growth rate of real GDP increases by 0.2 percentage points.

When we include the second lag of the *cdr* term, it leads to a considerable increase in the parameter value and the significance level of the first lag of the *cdr* term. However, it turns out that the parameter value of the second lag of the *cdr* term has a negative sign and is roughly the same size as the parameter value of the first lag (specification II). Thus, our results indicate that recessions in general are not followed by particularly strong recoveries.

In specification III, we allow for heterogeneity among recessions and augment the first specification by the first lag of the interaction terms for recessions associated with banking crises and housing crises and for recessions associated with pure housing crises. The parameter value of the *cdr* term increases considerably and is highly significant. The coefficient estimate of 0.97 for the term $cdr_{t-1,i}$ indicates that for every 1% that GDP falls

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[8] However, in Appendix B in our online appendix, we show that the baseline results presented in Section 4 are robust when we control for these five pure banking crises.

Table 1:
Estimation Results

	I	II	III	IV	V	VI
$\Delta y_{t-1,i}$	0.46*** (10.6)	0.62*** (11.9)	0.52*** (11.8)	0.65*** (12.7)	0.44*** (10.5)	0.47*** (9.7)
$\Delta y_{t-2,i}$	-0,05 (1.3)	-0.18*** (3.9)	-0,07* (1.8)	-0.20*** (4.2)	0.01 (0.3)	-0.01 (0.3)
$cdr_{t-1,i}$	0.20*** (2.7)	0.60*** (5.6)	0.97*** (5.8)	1.24*** (7.0)	0.71*** (5.0)	0.76*** (4.8)
$cdr_{t-2,i}$		-0.56*** (5.3)		-0.63*** (3.5)		-0.13 (0.8)
$cdr^{bc,hc}_{t-1,i}$			-0,96*** (5.6)	-0,99*** (5.1)	-0.68*** (5.1)	-0.75*** (5.0)
$cdr^{bc,hc}_{t-2,i}$				0.30 (1.4)		0.14 (0.8)
$cdr^{hc}_{t-1,i}$			-0.57*** (3.1)	-0.44** (2.1)	-0.41*** (2.7)	-0.34** (2.0)
$cdr^{hc}_{t-2,i}$				-0.04 (0.2)		-0.06 (0.3)
Time fixed effects	No	No	No	No	Yes	Yes
AIC	1.44	1.40	1.39	1.35	0.73	0.72
F-Test						
Banking and housing crises			0.92	0.31	0.72	0.80
Pure housing crises			0.00	0.11	0.00	0.02

Notes: t-values in parentheses. F-test shows the *p*-values resulting from the hypothesis that the parameter values of the *cdr* terms and of the banking and housing crises interaction term or the pure housing crises interaction term are identical. AIC shows the value of the Akaike Information Criterion. $cdr_t^{bc,hc}$ indicates a recovery following a recession associated with a banking and housing crisis. cdr_t^{hc} indicates a recovery following a recession associated with a housing crisis. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

below its previous peak during normal recessions, the growth rate of real GDP increases by 0.97 percentage points. This result indicates a significant bounce-back effect following normal recessions as deeper recessions are associated with more robust subsequent economic growth. When the recession is associated with a banking and housing crisis, this bounce-back effect vanishes completely; the parameter value of the interaction term $cdr_{t,i}^{bc,hc}$ takes on a value of -0.96. When the recession is associated with a pure housing crisis, the parameter value of the interaction term is -0.57, which suggests that the bounce-back effect is significantly weaker compared to recoveries following normal recessions (the growth rate of GDP increases only by 0.4 percentage points for every 1% that GDP falls below its previous

peak)[9]. In specification IV, we augment the model by a second lag for each *cdr* term. It turns out that the business cycle effects in the first year following a recession are even more pronounced than in specification III. For the second year, the parameter values have the opposite sign, indicating some repercussive effect for each type of recession (with or without a severe crisis). Overall, the effects are qualitatively similar, albeit somewhat weaker than those in specification III.

The Akaike Information Criterion (AIC) favors the specifications that include the interaction terms for banking crises and housing crises and exhibit the lowest value for the specification IV, which includes two lags of each variable. A likelihood-ratio test indicates that specification IV fits the data better than specification I (p-value: 0.00), specification II (p-value: 0.00), and specification III (p-value: 0.05).

In the specifications (V) and (VI), we include time fixed effects to control for global developments. Controlling for global developments is an important robustness check because macroeconomic conditions have changed between 1970 and 2012 and because recessions and severe crises were internationally synchronized to some degree in the past. Overall, when including time fixed effects the results are qualitatively the same. However, the parameter values of the *cdr* terms are somewhat smaller, indicating that some of the recessions, banking crises, and housing crises in our sample were indeed internationally synchronized.

Our results are also qualitatively robust with regard to several other robustness checks. Most importantly, our results are robust when we exclude the recessions, banking crises, and housing crises since 2007 from our sample and restrict our estimation period to 1970 to 2006. Moreover, our results are robust when we control for pure banking crises in our sample, when we allow for more-cross country heterogeneity in our model, when we use alternative

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[9] F-tests indicate that the parameter values of $cdr_{t,i}$ and $cdr_{t,i}^{bc,hc}$ are not significantly different from each other (in absolute terms), while the parameter values of $cdr_{t,i}$ and $cdr_{t,i}^{hc}$ are significantly different from each other (in absolute terms) with a p-value of 0.00.

identification criteria for housing crises, and when we include a global variable in our model to explicitly control for the impact of global factors.[10]

5 Conclusion

We provide empirical evidence that normal recessions are typically followed by strong recoveries and a bounce-back in the level of output. We find that the recovery becomes relatively stronger the deeper the preceding recession was. We also find that when a recession is associated with a banking crisis and a housing crisis this bounce-back effect is completely absent. Moreover, when a recession is associated with a pure housing crisis, the recovery is significantly weaker compared to a recovery following a normal recession. Our results suggest that recessions associated with banking and housing crises or with pure housing crises lead to considerably larger permanent output losses than normal recessions. Our findings are robust when we apply several robustness checks. In particular, our results are robust when we exclude the recessions and banking and housing crises of the years 2008 and 2009 and the subsequent recoveries from our sample.

[10] The robustness checks are available in the online appendix.

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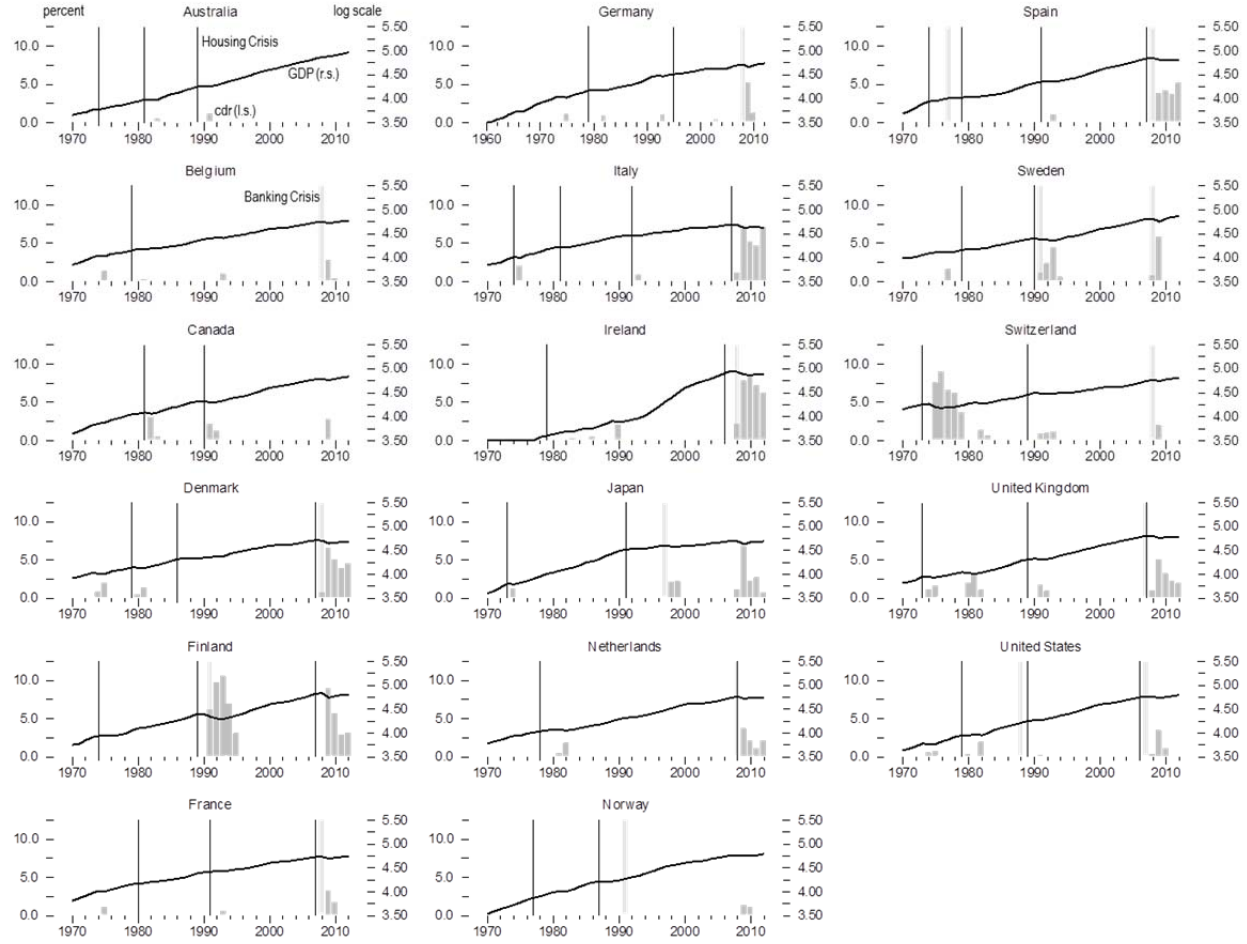
Appendix

In the Appendix, we check the robustness of our results when we control for pure banking crises (Appendix B); when we exclude the most recent recessions, banking crises, and housing crises from our estimation period and restrict our estimation period to 1970 to 2006 (Appendix C); when we allow for more cross-country heterogeneity in our model (Appendix D); when we use alternative identification criteria for housing crises (Appendix E); and when we include a global variable in our model to control for the impact of global factors on our results (Appendix F). All robustness checks indicate that our baseline results are qualitatively robust. In the first part of the appendix, we provide a graphical overview of our data set (Appendix A).

Appendix A: Data overview

Our data set is presented in Chart 1. We show log real GDP, and the *cdr* term for each country in our sample. We also indicate the years that mark the start of a banking crisis (with a shaded vertical area) or a housing crisis (with a vertical line). The *cdr* terms show that the recessions and recoveries differ considerably in terms of their depth and their length. Our sample of banking crises is strongly influenced by the Global Financial Crisis that begun in the years 2007 and 2008, given that 12 out of 18 banking crises started in that period. The influence is less strong for our sample of housing crises (9 out of 43) and for our sample of recessions (16 out of 60).

Chart 1:
GDP, indicator of current depth of recession, banking crises, and housing crises



Notes: Vertical lines indicate the year in which a housing crisis began. Vertical bars indicate the year in which a banking crisis began.

Appendix B. Controlling for pure banking crises

We have only five pure banking crises in our sample (banking crises associated with a recession but not with a housing crisis). Due to the limited number of observations it is not possible to robustly estimate the effect of a pure banking crisis on the strength of a recovery. Therefore, we decided not to account for pure banking crises in our baseline specification. However, in doing so, we implicitly interpret pure banking crises as normal recessions, which might affect our results. As a robustness check, we include in our baseline regression (3) an additional interaction term cdr^{bc} to control for pure banking crises.

The results for the strength of recoveries following normal recessions, following recessions associated with banking and housing crises, and following recessions associated with pure housing crises remain basically the same when controlling for pure banking crises (Table A.1).

Table A.1:
Estimation results when controlling for pure banking crises

	I	II	III	IV
$\Delta y_{t-1,i}$	0.52***	0.65***	0.44***	0.47***
	(11.8)	(12.6)	(10.5)	(9.7)
$\Delta y_{t-2,i}$	-0,07*	-0.20***	0.01	-0.02
	(1.8)	(4.2)	(0.3)	(0.4)
$cdr_{t-1,i}$	0.89	1.25***	0.70***	0.82***
	(4.2)	(5.4)	(4.2)	(4.4)
$cdr_{t-2,i}$		-0.71***		-0.26
		(3.0)		(1.4)
$cdr_{t-1,i}^{bc,hc}$	-0,88***	-1,00***	-0.68***	-0.81***
	(4.2)	(4.2)	(4.2)	(4.4)
$cdr_{t-2,i}^{bc,hc}$		0.38		0.27
		(1.5)		(1.4)
$cdr_{t-1,i}^{hc}$	-0.50**	-0.45*	-0.40**	-0.39**
	(2.2)	(1.8)	(2.3)	(2.0)
$cdr_{t-2,i}^{hc}$		0.11		0.07
		(0.4)		(0.4)
$cdr_{t-1,i}^{bc}$	0.17	0.01	0.01	-0.09
	(0.6)	(0.0)	(0.0)	(0.4)
$cdr_{t-2,i}^{bc}$		0.17		0.30
		(0.5)		(1.2)
Time fixed effects	No	No	Yes	Yes
AIC	1.39	1.35	0.73	0.72
F-Test	0.94/0.00	0.30/0.11	0.72/0.00	0.76/0.02

Notes: t-values in parentheses. First values of F-tests indicate the *p*-value of the hypothesis that the parameter values for the *cdr* terms and the banking crises and housing crises interaction terms are identical. Second values refer to the pure housing crises interaction term. AIC shows the value of the Akaike Information Criterion. $cdr_t^{bc,hc}$ indicates a recovery following a recession associated with a banking and housing crisis. cdr_t^{bc} indicates a recovery following a recession associated with a (pure) banking crisis. cdr_t^{hc} indicates a recovery following a recession associated with a banking and housing crisis. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

Appendix C. Controlling for the Global Financial Crisis

Our results might be strongly influenced by the Global Financial Crisis that begun in the years 2007 and 2008. This might be particularly true for our results with regard to banking crises because more than half of our observations of banking crises are banking crises that started since 2007. To test the robustness of our results with regard to the Global Financial Crisis, we

estimate our baseline model (3) for the period from 1970 to 2006 instead of for the period from 1970 to 2012.

Table A.2:
Estimation results for the period from 1970 to 2006

	I	II	III	IV
$\Delta y_{t-1,i}$	0.49***	0.51***	0.45***	0.45***
	(11.0)	(10.2)	(10.0)	(8.8)
$\Delta y_{t-2,i}$	-0,10**	-0.13***	0.00	-0.00
	(2.4)	(2.8)	(0.1)	(0.0)
$cdr_{t-1,i}$	0.92***	1.01***	0.87***	0.86***
	(3.4)	(3.5)	(3.6)	(3.4)
$cdr_{t-2,i}$		-0.27		-0.04
		(0.9)		(0.2)
$cdr^{bc,hc}_{t-1,i}$	-0,91***	-1,25***	-0.82***	-1.00***
	(3.2)	(3.8)	(3.3)	(3.4)
$cdr^{bc,hc}_{t-2,i}$		0.55*		0.27
		(1.7)		(0.90)
$cdr^{hc}_{t-1,i}$	-0.61**	-0.52*	-0.56**	-0.55**
	(2.2)	(1.7)	(2.3)	(2.0)
$cdr^{hc}_{t-2,i}$		0.00		0.01
		(0.0)		(0.1)
Time fixed effects	No	No	Yes	Yes
AIC	1.14	1.13	0.72	0.72
F-Test	0.93/0.01	0.66/0.09	0.60/0.00	0.38/0.01

Notes: t-values in parentheses. First values of F-tests indicate the *p*-value of the hypothesis that the parameter values for the *cdr* terms and the banking crises and housing crises interaction terms are identical. Second values refer to the pure housing crises interaction term. AIC shows the value of the Akaike Information Criterion. $cdr_t^{bc,hc}$ indicates a recovery following a recession associated with a banking and housing crisis. cdr_t^{hc} indicates a recovery following a recession associated with a banking and housing crisis. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

Our results are robust when excluding the Global Financial Crisis that begun in the years 2007 and 2008 from our estimation period (Table A.2). In general, there is a tendency that the strength of recoveries following normal recessions and the dampening effects of banking and housing crises as well as pure housing crises had been somewhat stronger before 2007 (except for specification I). Overall, the robustness of our results with regard to the estimation period suggests that our model would have had some out-of-sample forecasting power for the recoveries following the Global Financial Crisis.

Appendix D. Allowing for more cross-country heterogeneity

In our baseline specification, we used a standard fixed effects estimator allowing for cross-country heterogeneity only in the constant term. In the following, we test whether our results are robust when allowing for more cross-country heterogeneity by using two approaches. Therefore, we estimate our model by using the seemingly unrelated regression (SUR) method and only restrict the parameter values of the *cdr* terms and the interaction terms between the cdr term and the crises dummies to be equal across countries. Thus, we allow for more cross-country heterogeneity than in our baseline specification. Moreover, when using the SUR method, we explicitly account for the cross-correlation in the error terms.

By using SUR, we also control to some degree for the impact of global factors that affect all countries in our sample contemporaneously.[11] However, a disadvantage of SUR is that we have to estimate the covariance matrix for 17 error terms, which could lead to imprecise parameter estimates given our relatively small dataset.[12] Therefore, we decided to use the SUR method only as a robustness check but not for our baseline results.

Overall, our results are robust when using the SUR method to estimate our model and when allowing for cross-country heterogeneity in the AR-terms (Table A.3). Overall, the dampening effect of banking and housing crises and of pure housing crises is estimated to be somewhat stronger relative to the estimated strength of a recovery following a normal recession compared to our baseline results.

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[11] In our baseline specification, we control for the impact of global factors with time fixed effects. In Appendix F, we control for the impact of global factors more explicitly by including a global GDP variable in our model.

[12] More concretely, we would have to estimate 136 additional parameters for the cross-correlations in the error terms based on a dataset of roughly 700 observations.

Table A.3:
Estimation results when using the SUR method and allowing for more country heterogeneity

	I	II
$\Delta y_{t-1,i}$	-	-
$\Delta y_{t-2,i}$	-	-
$cdr_{t-1,i}$	0.72*** (7.1)	0.94*** (8.0)
$cdr_{t-2,i}$		-0.34*** (2.8)
$cdr^{bc,hc}_{t-1,i}$	-0,81*** (7.9)	-0,88*** (7.5)
$cdr^{bc,hc}_{t-2,i}$		0.10 (0.8)
$cdr^{hc}_{t-1,i}$	-0.61*** (6.1)	-0.27** (2.2)
$cdr^{hc}_{t-2,i}$		-0.37*** (2.8)
AIC	1.35	1.32
F-Test	0.15/0.19	0.00/0.54

Notes: t-values in parentheses. First values of F-tests indicate the *p*-value of the hypothesis that the parameter values for the *cdr* terms and the banking crises and housing crises interaction terms are identical. Second values refer to the pure housing crises interaction term. AIC shows the value of the Akaike Information Criterion. $cdr^{bc,hc}_t$ indicates a recovery following a recession associated with a banking and housing crisis. cdr^{hc}_t indicates a recovery following a recession associated with a banking and housing crisis. '-' indicates freely estimated parameters across countries. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

Appendix E. Identification of Housing Crises

We check the robustness of our results with respect to the identification criteria for housing crises and with respect to the criteria used to identify when recessions are associated with banking and housing crises.

In our baseline model, we identify housing crises as a centered nine-year high of house prices. Although this criterion is transparent, provides reasonable and stable results, and is in line with the literature (Ahearne et al. 2005), it is rather ad hoc. Therefore, we check the robustness of the results by modifying our identification criteria with respect to two alternative but related identification criteria that have been applied in the literature. First, we

follow Jannsen (2010) and Aßmann et al. (2012) and define the starting year of a housing crisis as the peak of real house prices within a rolling window of nine years followed by a price decline of at least 7.5 percent within the first four years following the peak.[13]

Table A.4:
Estimation results for alternative identification criteria for housing crises

	House price decline of at least 7.5 percent		25 percent of the most severe house price declines	
	I	II	III	IV
$\Delta y_{t-1,i}$	0.44***	0.47***	0.43***	0.47***
	(10.4)	(9.7)	(10.0)	(9.5)
$\Delta y_{t-2,i}$	0,01	-0.02	0.01	-0.03
	(0.3)	(0.5)	(0.3)	(0.6)
$cdr_{t-1,i}$	0.58***	0.76***	0.35***	0.52***
	(4.6)	(5.0)	(4.0)	(4.4)
$cdr_{t-2,i}$		-0.38**		-0.27**
		(2.5)		(2.2)
$cdr^{bc,hc}_{t-1,i}$	-0,54***	-0.72***	-0.35***	-0.65***
	(4.5)	(4.8)	(3.5)	(4.2)
$cdr^{bc,hc}_{t-2,i}$		0.37**		0.42**
		(2.2)		(2.5)
$cdr^{hc}_{t-1,i}$	-0.34**	-0.51***	0.10	-0.18
	(2.3)	(2.7)	(0.2)	(0.3)
$cdr^{hc}_{t-2,i}$		0.37*		0.79
		(1.9)		(1.4)
$cdr^{bc}_{t-1,i}$	0.15	0.01	-0.23*	-0.30**
	(0.8)	(0.0)	(1.9)	(2.0)
$cdr^{bc}_{t-2,i}$		0.38*		0.08
		(1.8)		(0.5)
Time fixed effects	Yes	Yes	Yes	Yes
AIC	0.79	0.71	0.75	0.74
F-Test				
Banking and housing crises	0.58	0.80	0.95	0.78
Pure housing crises	0.02	0.04		
Pure banking crises			0.32	0.81

Notes: t-values in parentheses. F-test shows the *p*-values of the hypothesis that the parameter values of the *cdr* terms and of the banking and housing crises interaction terms, the pure housing crises interaction terms, or the pure banking crises interaction terms are identical.. AIC shows the value of the Akaike Information Criterion. $cdr_t^{bc,hc}$ indicates a recovery following a recession associated with a banking and housing crisis. cdr_t^{bc} indicates a recovery following a recession associated with a pure banking crisis. cdr_t^{hc} indicates a recovery following a recession associated with a pure banking. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

[13] Based on these criteria to identify housing crises, we have 38 housing crises in our sample, 29 recessions that are associated with housing crises, 10 recessions that are associated with a banking crisis and a housing crisis, and 19 recessions associated with 'pure' housing crises.

Second, we identify only the 25 percent strongest house price declines in the first four years following a price peak as a housing crisis, which is in line with the IMF (2003).[14] Our results change somewhat when we use the alternative identification criteria to identify housing crises (Table A.4). This is particularly true when we only identify the top 25 percent of the strongest house price declines as a housing crisis (specifications III and IV). In these specifications, the strength of a recovery following a normal recession is considerably lower compared to our baseline results. Moreover, in these specifications, pure housing crises do not significantly dampen the strength of a recovery while pure banking crises significantly dampen the strength of a recovery. However, when interpreting the results of these robustness checks it is important to note that when using alternative identification criteria for housing crises, we have a composition effect in the identified normal recessions and in the recessions associated with banking crises and housing crises. When using more restrictive identification criteria for housing crises (or identifying fewer house price declines as housing crises), we basically interpret some of the recessions that have been interpreted in our baseline model as recessions associated with housing crises as normal recessions. Moreover, we have fewer recessions associated with banking crises and housing crises and more recessions associated with pure banking crises in our sample. Therefore, the results of a weaker recovery following a normal recession and no dampening effects of pure housing crises also indicate that housing crises with smaller house price declines are important indicators for the strength of recoveries and that our baseline specification for housing crises is reasonable.

Appendix F. Accounting for Global Factors

Country-specific business cycle dynamics are influenced by the global economy (Kose et al., 2003). To control for the influence of global factors, we included time fixed effects in our baseline model. While including time fixed effects is the most straightforward way to control

[14] Based on these criteria to identify housing crises, we have 11 housing crises in our sample, 10 recessions that are associated with housing crises, 3 recessions that are associated with a banking crisis and a housing crisis, and 7 recessions associated with 'pure' housing crises. When using these identification criteria, we have too few observations to precisely estimate the dampening effects of banking and housing crisis on the strength of a recovery. However, we leave the corresponding interaction term in the regression as a control variable because otherwise these recessions would be treated as normal recessions.

for the influence of global factors, it is rather crude because it assumes that the influence is equal over all countries and it requires more than 40 additional parameters to be estimated.

As a second method of controlling for the influence of the global business cycle dynamics, we include a global output variable in the baseline model. We calculate global output for each economy individually as export-weighted GDP growth of the other economies in our sample.[15] Because the most important advanced economies are included in our sample, the calculated global variable is a reasonable approximation of the global business cycle from the perspective of each individual economy. Including the global variable Δy_t^*, the model is defined as

$$\Phi(L)\Delta y_{t,i} = \alpha_i + [\Omega(L)-1]cdr_{t,i} + [\Gamma(L)-1]cdr_{t,i}^{bc} + \Pi(L)-1]cdr_{t,i}^{hc} + \Lambda(L)\Delta y_{t,i}^{*} + \varepsilon_{t,i}\,. \qquad (5)$$

We assume that each country is small compared to the world and therefore allow for contemporaneous effects of the global economy on domestic GDP growth.[16]

The global GDP variable is highly significant (Table A.5, specifications I and II). The results for the strength of recoveries are basically the same as in our baseline model that accounts for time fixed effects. Not surprisingly, when we account for time fixed effects, the parameter values as well as the t-values of the global variable decrease dramatically (specifications III and IV). However, the results for the strength of recoveries are again basically the same.

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[15] Export data were taken from the International Financial Statistics Database of the IMF.

[16] This assumption is obviously questionable for the United States but reasonable for the other countries in our sample. The method of calculating the global term is inspired by the growing literature that uses export-weighted or, alternatively, trade-weighted foreign variables to account for global developments (see Abeysinghe and Forbes, 2001; Pesaran et al., 2004).

Table A.5:
Estimation Results when extending the model by a global variable

	I	II	III	IV
$\Delta y_{t-1,i}$	0.49***	0.52***	0.45***	0.48***
	(12.3)	(11.7)	(10.8)	(10.0)
$\Delta y_{t-2,i}$	-0,01	-0.04	0,01	-0.02
	(0.2)	(1.2)	(0.3)	(0.4)
$cdr_{t-1,i}$	0.62***	0.69***	0.73***	0.79***
	(4.9)	(5.1)	(5.3)	(5.0)
$cdr_{t-2,i}$		-0.20		-0.14
		(1.4)		(0.9)
$cdr_{t-1,i}^{bc,hc}$	-0,62***	-0.73***	-0,71***	-0.77***
	(4.9)	(5.0)	(5.4)	(5.2)
$cdr_{t-2,i}^{bc,hc}$		0.23		0.15
		(1.5)		(0.9)
$cdr_{t-1,i}^{hc}$	-0.39***	-0.32**	-0.46***	-0.41**
	(2.8)	(2.0)	(3.2)	(2.5)
$cdr_{t-2,i}^{hc}$		-0.03		-0.02
		(0.2)		(0.1)
$\Delta y_{t,i}^{*}$	0.86***	0.85***	0.42***	0.42***
	(23.0)	(22.2)	(3.8)	(3.8)
$\Delta y_{t-1,i}^{*}$	-0.27***	-0.28***	-0.38***	-0.37***
	(5.6)	(5.6)	(3.4)	(3.2)
Time fixed effects	No	No	Yes	Yes
AIC	0.79	0.79	0.70	0.69
F-Test				
Banking and housing crises	0.96	0.80	0.72	0.82
Pure housing crises	0.01	0.04	0.00	0.03

Notes: t-values in parentheses. F-test shows the *p*-values of the hypothesis that the parameter values of the *cdr* terms and of the banking and housing crises interaction terms or the pure housing crises interaction terms are identical. AIC shows the value of the Akaike Information Criterion $cdr_t^{bc,hc}$ indicates a recovery following a recession associated with a banking and housing crisis. cdr_t^{hc} indicates a recovery following a recession associated with a housing crisis. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively.