CRISIS, POTENTIAL OUTPUT AND HYSTERESIS
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CRISIS, POTENTIAL OUTPUT AND HYSTERESIS

By Annabelle Mourougane

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Abstract

This paper seeks to estimate the effects of financial crises on potential output accounting for hysteresis on a panel of 34 OECD economies. Hysteresis amplifies the effect of financial crises on potential output. The difference is marginal in the first years (below 0.5 percentage point) but grows over time to reach some 1.5 percentage points after four years, almost doubling the crisis impact on potential output at this horizon. These results are robust to a range of specifications. On average across crisis and country the maximum crisis effect on potential output is about 3%. The effect appears to be more severe for the 2008 crisis though, with a maximum impact above 4% on average for G7 countries. Small euro area countries and the United Kingdom appear to have suffered from bigger losses than the United States and Canada. Large euro area countries and Japan are estimated to be in an intermediary situation. Lastly, the empirical work undertaken in this paper suggests that financial crises have had on average an effect on potential growth in the first years following the crisis but not after.

1. Introduction

There is now a wide consensus that deep recessions can have persistent effects on the level of potential output. The latter falls because a recession reduces capital accumulation, leaves

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scars on unemployed whose skills, motivation and attachments to labour markets erode and slows technological progress. These long-term effects reflect what is usually called “hysteresis”, whereby a transitory shock can have a permanent effect through a memory process. As a result the path of potential output depends not only on current inputs, but also on the history of past outputs.

Lately, a number of papers have concluded that developed economies may have suffered from permanent production losses in the aftermath of financial crises, but the extent of these losses is still debated and usually ranges between 4 and 10 %, with a lower amount for OECD countries (Cerra and Saxena, 2008; Furceri and Mourougane, 2012; European Commission, 2009; Ollivaud and Turner, 2014). However, thus far, most models have not explicitly accounted for hysteresis and are likely to underestimate permanent losses stemming from financial crises. Moreover, only few analyses have investigated the effects of financial crises on potential growth.

Against this background, this paper seeks to cast light on two issues. First, it estimates the effects of financial crises on potential output accounting for hysteresis on a panel of 34 OECD economies. For this purpose, the model draws on Cerra and Saxena (2008), Furceri and Mourougane (2012) and Teuling and Zubanov (2010). It is enriched to incorporate hysteresis following Kapadia (2005) according to whom a deviation from actual growth leads to a permanent change in potential growth. Second, it examines whether financial crises affect the growth of potential output over the long term.

The main findings of the paper are the following. Accounting for hysteresis amplifies the effect of financial crises on potential output. The difference is marginal in the first years (below 0.5 percentage point) but grows over time to reach some 1.5 percentage points after four years, almost doubling the crisis impact on potential output at this horizon. These results are robust to a range of specifications. On average across crisis and country the maximum
crisis effect on potential output is about 3%. The effect appears to be more severe for the 2008 crisis though, with a maximum impact above 4% on average for G7 countries. Small euro area economies and the United Kingdom suffered from bigger losses than the average OECD countries, while the United States and Canada experienced lower losses. Large euro area economies and Japan are estimated to be in an intermediary situation. Lastly, the empirical work undertaken in this paper also suggests that financial crises have had an effect on potential growth in the first years following the crisis but not after. This indicates that financial crises are likely to have a permanent effect on the level of potential output though not on its growth.

The paper unfolds as follows. The second section briefly reviews the main channels through which a financial crisis can impact potential output, focusing on hysteresis phenomena, and how the latter have been estimated in the economic literature. The third section presents the model used to estimate those impacts. The fourth section describes the data and the empirical approach. The fifth discusses the main results and a last section concludes.

2. Literature review

2.1. There is a consensus that financial crisis can impact the level of potential output

Financial crises impact potential output through a range of channels. Direct effects are visible on all the components of the production function, namely capital input and labour and total factor productivity (TFP) in standard specifications. Financial crises lower incentives to invest in capital by decreasing demand for products and raising uncertainty on investment returns and risk premia (Pindyck, 1991; Pindyck and Solimano, 1993; Janicko et al., 2012). A decrease in investment growth can translate into durable effects on potential output as a lack of capital reduces future productive capacity and leads to aging capital. Moreover, firms may have to cope with less advantageous investment
financing conditions due to tighter lending standards in the form of an increasing real cost of borrowing, stricter collateral requirements and/or limited credit supply. This could constrain them to stick with less efficient production process.

On labour markets, Ravn and Stern (2012) show that a major uncertainty shock can result in large increases in unemployment because of a declining matching efficiency. Moreover, a cyclical change in labour demand can lead to a supply adjustment through insiders/outsiders effects (Blanchard et Summers, 1987; Lindback et Snower, 1988) or skill losses (Pissarides, 1992). In the insiders/outsiders model, trade unions or lobbies defend the interest of their members in wage negotiations, which can lead to a lower level of employment for those who are not part of the group when the recession ends. Skill losses can occur when long-term unemployed or discouraged job seekers see their human or social capital deteriorating. Recent evidence is however less conclusive on the role of job spells in deepening the economic damages to worker from a financial crisis. Despite the clear evidence that involuntary job loss of any duration leaves economic scars on households and workers, the worsening of these scars by long-lasting jobless spells is actually quite thin (Bivens, 2014). Still long unemployment duration is often used as a signalling mechanism of the productivity of potential hires: firms are reluctant to employ staff who have not worked for a long time and are considered costly to re-employ (Llaudes, 2005).

The effect of the crisis on labour force participation combines a discouraged worker effect – whereby the deterioration in labour markets incites workers to leave the labour force and an encouraged workers effect – where the loss in revenue encourages second-earner to seek a new job and to enter the labour force. Evidence from the literature suggests that discouraged worker effect can be significant (Elmeskov and Pichelman, 1993) and has been dominant in developed countries (Lee and Parasnis, 2014). Erceg and Levin (2013) and Hall (2014) found that, for the recent crisis, the shortfall of labour force participation from its pre-crisis trend
was about 2 percentage points in the United States. However, past evidence suggests that the encouraged worker effect can be also important, in particular for females (Debelle and Vickery, 1998).

The crisis impact on $TFP$ has been identified as the main factor explaining country differences in potential output in the aftermath of a crisis (Koopman and Székely, 2009). Many factors are at play and their combining effect on potential output depends on their relative importance:

- A decline in investment can slow TFP. This is for instance the case for RD spending, which is usually pro-cyclical;
- A slower sectoral reallocation can restrain productivity by limiting resources devoted to the most productive sectors;
- By contrast, a crisis can favour innovation and have persistent effects on productivity at least in some sectors such as railways (Field, 2012).

Overall, a growing number of studies have found that deep recessions in the world have had a highly persistent effect on the level of potential output. This effect is estimated to range between 1.5 and 20 % but most studies conclude to an average effect of crises between 4 and 10 %. The effect is estimated to be lower for OECD countries (cf. Annex 1). The impact is estimated to be much less pronounced for developed economies 51% in Cerra and Saxena (2009) and 1.5-2% in Fuereri and Mourougane (2012).

2.2. ... but evidence of the growth impact of financial crises is scarce

Past crises’ experiences and economic analyses suggest that three configurations are possible after a severe financial crisis such as those of 2008:

- A rupture scenario: the crisis is accompanied by both a loss in the level of potential output and potential growth rates decline (Japan, early 1990s).
A setback scenario: the initial deceleration is followed by a partial recovery phase. The loss of production level is final, but the crisis has no effect on the potential growth rates (Sweden, 1994).

A rebound scenario: the economy goes back on the growth path that would have existed without the crisis. The crisis has no effect on either the level or the growth rate of potential output (Mexico, 1994).

Economic studies suggest that the rupture and setback scenarii are the most likely, but are often unable to discriminate between the two hypotheses. Two studies have found that crises are unlikely to affect potential growth, but the evidence is thus far relatively scarce (INSEE, 2010; European Commission, 2009). In other words, if the crisis is estimated to have a permanent effect on the level of potential output, there are still uncertainties about the expected effects on its medium-term growth rate.

2.3. ... and hysteresis effects are hard to quantify

Six years after the collapse of Lehman Brothers, output is still depressed in many countries (OECD, 2014). This suggests that the extent of hysteresis and/or its impact on the economy may have been underestimated in previous evaluations. One reason may be that most empirical models which estimate the effects of financial crises do not explicitly account for hysteresis. When the latter is incorporated in the analysis it is in an ad hoc and partial way, most of the time through an autoregressive process.

This simplifying assumption stems from the difficulty of quantifying the degree of hysteresis. First, it is difficult to disentangle the effects coming from hysteresis from those reflecting trend changes due to a technological or a population shock. Second, stabilisation policies are likely to affect hysteresis.

Hysteresis in unemployment is usually tested by examining the stationarity of the series but this approach does not provide an estimate of the extent of hysteresis (Khim-Sen Liew et al.,
In the majority of economic papers the hysteresis coefficient, that measures permanent output losses stemming from the memory process, is calibrated. Fritsche and Gootschalk (2005) and Mankiw (2001) set it at 0.1 and Kapadia (2005) at 0.25. Most recently, there have been a few attempts to estimate hysteresis. Using a production function approach, Delong and Summers (2012) measure hysteresis on potential output through the pro-cyclical adjustment of capital stock and labour supply in the United States, France, Germany, Italy and the United Kingdom. The degree of hysteresis would be comprised between 0 and 0.2, being close to 0.1 in the flexible US labour markets. Logeay and Tober (2006) point to a degree of hysteresis of 0.3 for euro area labour markets for the period 1973-2002. Kienzler and Schmid (2013) found that a 0.2-0.3 value is plausible and that 0.3 is consistent with US data. A too high value would lead to a negative correlation between inflation and growth in case of a monetary policy shock and would thus not be plausible.

More recently, Rawdanowicz et al. (2014) compute hysteresis parameters for OECD countries by dividing the estimated crisis-related hit to potential output derived in Ollivaud and Turner (2014) by the cumulative negative output gaps over the period 2009-14. Those parameters are close to 0.1 in the United States and significantly higher in many European countries, especially in Eastern European countries. Overall, despite recent progress, evidence on the amplitude of hysteresis remains limited.

3. The model

In this paper, the model draws on Cerra and Saxena (2008) and Furceri and Mourougane (2012) who seek to estimate the effect of crises on potential output by regressing the latter on a dummy that captures the start of a crisis. The specification is adapted following Teuling and Zubanov (2010) iterative specification, in which reaction functions are locally computed. Such a formulation has for instance been used to assess the impact of the crisis on labour
force participation (Duval et al., 2011). Its advantage is that the crisis impact is independent from the lag structure of potential output.

More specifically, the dynamics of potential output is given by:

$$\forall k = 1 \ldots T \quad y_{i,t+k}^* - y_{i,t}^* = \alpha_{i,k} + \sum_{j=1}^{l} \beta_{j,k} \Delta y_{i,t-j}^* + \delta_k D_{i,t} + \varepsilon_{i,t+k}$$  \hspace{1cm} (1)

$y_{i,t}^*$ is the log of potential output, with $l$ is the number of lags in the process

$D_{i,t}$ is a dummy which is equal to 1 at the start of a financial crisis

$\alpha_{i,k}$ is a country fixed effect

The crisis impact at period $k$ is directly given by the parameter $\delta_k$. Two noteworthy changes to this basic model have been added.

The first amendment aims at testing whether crises have an impact on potential growth. For this purpose, the possibility of having a change in the constant has been included, when the difference between potential and actual growth is above 1 point i.e. the drop in demand is sufficiently large to affect supply. When the break is significant, the crisis is estimated to affect potential growth, so that a path with lower potential growth in the future cannot be excluded.

Equation (1) thus becomes

$$\forall k = 1 \ldots T \quad y_{i,t+k}^* - y_{i,t}^* = \alpha_{i,k} + \theta_k C_{i,t} + \sum_{j=1}^{l} \beta_{j,k} \Delta y_{i,t-j}^* + \delta_k D_{i,t} + \varepsilon_{i,t+k}$$  \hspace{1cm} (2)

where $C_{i,t}$ equals $n$ if the country has had $n$ banking crises before year $t$.

The second amendment is to incorporate hysteresis following Kapadia (2005) according to whom a deviation of actual growth from potential growth leads to a permanent change in potential growth:

$$y_{i,t}^* = a_i + \rho_a y_{i,t-1}^* + \mu (y_{i,t-1} - y_{i,t-1}^*) + u_t^a = a_i + (\rho_a - \mu) y_{i,t-1}^* + \mu (y_{i,t-1}) + u_t^a$$  \hspace{1cm} (3)

$y_{i,t}$ is the log of actual output
\( \mu \) is the degree of hysteresis, \( \mu > 0 \)

\( u \) is a productivity shock of zero mean and of variance \( \sigma_u \)

\( \rho_\alpha \) is the past impact of the productivity shock

Combining this formula with (2) gives

For all \( k = 1 \ldots T \)

\[
y_{i,t+k}^* - y_{i,t}^* = \alpha_{i,k} + \theta_k C_{i,t} + \sum_{j=1}^{l} \left[ \beta_{j,k} \Delta y_{i,t-j}^* + \mu_{j,k} (\Delta y_{i,t-j}^* - \Delta y_{i,t-j}^*) \right] + \delta_k D_{i,t} + \epsilon_{i,t+k}\tag{4}
\]

In this specification, \( \delta_k + \theta_k \) is the impact of the crisis and \( \mu_{j,k} \) the hysteresis effect. \( l \) is the length of the memory process.

Modelling hysteresis in alternative ways such as those proposed by Kiezler and Schmid (2013) \((y_{it}^* = a_i + (1 - \mu)\rho a y_{i,t-1}^* + \mu y_{i,t-1} + u_t^2)\) or Fritsche and Gottschalk (2005) or Mankiw (2001 for unemployment) \((y_{it}^* = a_i + \rho a y_{i,t-1}^* + \mu (y_{i,t-1}) + u_t^2 \text{ with } \mu = 0.1 )\) would only change the autoregressive term and not modify the results. One limitation of this assumption is, however, that hysteresis is modelled as a linear process while it could be non linear.

### 4. Estimation and data

Equation (4) is estimated on an unbalanced panel of 34 OECD countries over the period 1983-2012 using GMM to account for endogeneity (Bond et al., 2001). Standard instruments have been used (namely lags of the explanatory variables and the Durbin ranks). Given the paucity of data it was judged preferable to introduce only one lag in the memory process \(( l = 1 )\). This is not a crucial assumption though as the effect of the crisis does not depend on the number of lags in the adopted specification. Following Teuling and Zubanov (2010), White robust standard errors have been computed.
The sample is restricted to OECD economies. Boyd et al. (2005) suggest that it may not be relevant to look at both developed and developing economies as those two groups of countries may be facing very different types of crises. Even though it is restricted to OECD countries, our sample includes a few countries (Mexico, Korea and Turkey) which have been more prone to serious financial crises than more advanced economies in the past. To address this issue, estimations have also been carried on excluding those countries.

Data from actual and potential output are taken from the OECD Economic Outlook database. Potential output is derived through a production function approach which is documented in Beffy et al. (2006) and Johansson et al. (2013). This method is standard and used in most international organisations.

Constructing a series to capture financial crises is challenging. It requires to identify crisis episodes, to date the start of those crises and eventually determine their duration. Recent economic literature suggests that differences in dating can alter the impact of crisis on growth. In this paper we use the crisis dummy constructed in Laeven and Valencia (2012). These authors have dated exchange-rate, sovereign debt and banking crises over the period 1960-2012 using several indicators such as bankruptcy numbers or non-performing loans. Only banking crises are considered in this paper, given the small number of debt crises that have occurred in OECD countries during the period. Exchange-rate crises are slightly more numerous but may be of less interest than banking crises in the current context.

The main advantage of the Laeven-Valencia dummy is that it codes the starting date of a crisis and thus prevents endogeneity problem that would occur if indicator of severity or duration were used. The endogeneity of the start of the crisis dummy is tested using a probit model. The latter suggests that the burst of a crisis does not depend on past potential growth rates (cf. Annex 2). Those results are robust to change in the estimation period (in particular
the inclusion of the 2008 crisis) and changes in the number of lags. Furceri and Mourougane (2012) found similar results.

5. Results

5.1. Financial crises appear to have on average an effect on potential growth in the first years following the crisis but not after

To start with, equation (2) has been estimated to compute the impact of financial crises in the absence of hysteresis. Estimations results are reported in Annex 3. In the standard model, which includes country and time fixed effects, crises are found to have a negative effect on the level of potential output. The effect is significant up to 6 years after the crisis. The maximal output loss amounts to around 2%, which is consistent with Furceri and Mourougane (2012), even though they use different specification, sample period and estimation method (Figure 1).

The inclusion of a time-fixed effect alters the profile of the reaction function. The differences are particularly marked after 6 years, but the effect is not significant at this horizon so that it is not possible to discriminate between the two profiles.
Crisis impact without hysteresis

Percentage of potential output

Crisis impact without hysteresis

Crises are found to affect potential growth only in the first years following the burst of the crisis. The inclusion of the constant break deepens the global effect of banking crises (Figure 1). This variable is significant, but only in the aftermath of the crisis and usually loses significance after four years, implying that a scenario of durable effect on potential growth is not likely. This is consistent with INSEE (2010) or European Commission (2009) and appears to be robust to several specifications.

5.2. Hysteresis effects are found to matter but only after few years

In a second step, equation (4) is estimated to incorporate hysteresis in the framework. The coefficient \( \mu_{j,k} \), which measures hysteresis, is significant. It is found to generally vary between 0.1 and 0.5, depending on the period and the specification used, and is close, though sometimes higher, to what has been estimated in the literature (Logeay and Tober, 2006; Kienzler and Schmid, 2013). The coefficient \( \delta_{k} \) remains significant up to six years after the crisis (cf. Annex 3).

Hysteresis marginally changes the crisis impact in the first years (by less than 0.5 percentage point) but the difference grows over time to reach some 1.5 percentage points after four years.
when hysteresis almost doubles the crisis impact on potential output (Figure 2). The relatively small amplitude of hysteresis effects, in the first years, is consistent with the intuition that it involves mechanisms that take times to materialise.

Figure 2. Crisis impact with and without hysteresis

Percentage of potential output

These results are robust to a range of tests (Figure 3). First, the global effect of banking crises on potential output is relatively similar, whether a time trend is included or not. Such trend is meant to capture structural developments, such as population ageing, which are expected to have an effect on potential output, independently from the crisis. The trend is significant but does not alter the sign nor the significance of the hysteresis coefficient. Second, estimation results do not change much when the constant break is excluded. Finally results hold whether Korea, Turkey and Mexico which experienced more severe crises in the past than the average OECD countries, are included or not. The direct crisis effect is nonetheless less marked when those three countries are excluded from the sample.
5.3. The crisis effect varies across country and over time

One of the limits of equation (4) is that it assumes that hysteresis effects are similar across country, whereas labour markets’ resilience varies widely across developed economies. Such differences are captured in country fixed-effects, but the latter also seize all the differences that are not explicitly accounted for in the specification (e.g. governance, openness…). One possibility to better account for country heterogeneity would be to estimate country-specific hysteresis coefficient. However, the small degree of freedom precludes this option. One alternative is to introduce an interaction term whereby the crisis impact will also depend on the extent of hysteresis experienced by individual countries.

∀k = 1 ... T

\[
y_{i,t+k} - y_{i,t} = \alpha_{i,k} + \theta_{k} G_{i,t} + \sum_{j=1}^{j} \left[ \beta_{j,k} \Delta y_{t-j}^{*} + \mu_{j,k} (\Delta y_{t-j} - \Delta y^{*}_{t-j}) + \rho_{k,j} (\Delta y_{i,t-j} - \Delta y^{*}_{i,t-j}) D_{i,t} \right] + \delta_{k} D_{i,t} + \varepsilon_{i,t+k} \quad (5)
\]
In such a specification, the crisis effect on potential growth is composed of a common effect $\delta_k$ which is similar in all the countries and an interaction effect $\rho_{k,j}(\Delta y_{i,t-j} - \Delta y^*_{i,t-j})$ which is country specific.

The introduction of the interaction term does not alter the preceding estimation results: hysteresis continues to deepen the crisis impact on potential output and there is no evidence of an effect of the crisis on potential growth in the long term. The significance of the hysteresis and of constant break terms is little changed (cf. Annex 3 for detailed results). The country-specific hysteresis effect, measured through the interaction between hysteresis and the crisis dummy is negative and significant but only in the first years following the crisis. This latter effect is moreover limited compared to the common effect.

**Figure 4. Country-specific and common crisis effect on potential output after four years**

Percentage of potential output

The average maximum crisis impact varies across country but only to a limited extent, one reason being that country fixed-effects already capture variation in structure across country.
Averaging the crisis impact over time also smoothes country differences. The crisis impact for the average of G7 countries is very close to those of the average OECD countries (Figure 5). On average across crisis and country the maximum effect is about 3%.

In addition to introducing country differentiation, such a model also permits to identify the effect of the 2008 crisis. Not surprisingly, the impact appears to be more severe for the 2008 crisis than for past crises, with a maximum impact above 4% on average for G7 countries.

Figure 5. Crisis impact on potential output in the average of G7 countries

The United States and Canada appears to be the ones for which losses were the smallest, while the United Kingdom was more severely affected. Japan and the three largest euro area countries, Germany, France and Italy, were in an intermediary situation. Smaller euro area economies have experienced significantly higher losses than their larger euro area counterparts (Figure 6).
Figure 6. **2008 crisis impact on potential output in selected countries**

Percentage of potential output

Note: the group ‘small economies’ is composed of Austria, Belgium, Finland, Luxembourg, Ireland, Greece, the Netherlands, Portugal and Spain.

### 6. Conclusion

This paper seeks to estimate the effect of financial crises on a panel of OECD countries. It expands on existing literature by explicitly incorporating hysteresis in the empirical work. Such effects are found to markedly deepen the impact of financial crises on potential output after 3 to 4 years, doubling the effect at this horizon. These results still hold whether a time trend or a constant break are included in the model or whether the sample comprises crisis countries or not. On average across crisis and country the crisis maximum effect is about 3%.

The effect appears to be more severe for the 2008 crisis though, with a maximum impact above 4% on average for G7 countries. Small euro area countries and the United Kingdom appear to have experienced stronger losses than the United States and Canada. Large euro area countries and Japan are estimated to be in an intermediary situation.

Lastly, financial crises are found to affect potential growth only in the first years following the crisis. This casts some doubt on the likelihood of a scenario, whereby the latest financial crisis could durably lower potential growth in OECD countries.
The analysis is subject to a number of caveats and could be extended in several ways. First, the empirical work has been undertaken at a very aggregate level and can hide wide disparity across sector. In this regard, undertaking a similar exercise at the sectoral level is likely to be very informative. Second and more importantly, a number of factors (governance is a case in point) that should influence the crisis impact could not be incorporated in the analysis, given the absence of reliable data to capture those factors. Finally, it may be useful to consider the asymmetry of hysteretic adjustment in terms of amplitude and timing.

Despite these limitations, these results have several policy implications. Hysteresis is found to have a non-trivial effect and needs to be explicitly and fully accounted for in policymaking decisions. Ignoring this effect could lead to a sizeable over-estimation of the magnitude of the output gap and to mis-judgment on the current economic situation, inflation pressures and fiscal stances. Moreover, policymakers need to implement measures to lessen hysteresis, through product and labour market reforms, as the latter markedly worsen the crisis impact on potential output.

**BIBLIOGRAPHY**


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### ANNEX 1: PAST EVALUATIONS OF THE IMPACT OF FINANCIAL CRISSES ON (POTENTIAL) OUTPUT

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<td>Demirgüç-Kunt et al (2006)</td>
<td>35 developed and developing economies 1980-1998</td>
<td>GDP growth rate equation avec dummy</td>
<td>The average GDP growth declines from 4 and 3.5 points the year the crisis occurs and the following year. Growth rate reverts to the pre-crisis levels two years after the crisis.</td>
</tr>
<tr>
<td>Furceri and Mourougane (2012)</td>
<td>OECD countries 1960-2007</td>
<td>Panel estimation on potential output estimated by the production function and trend GDP (filtered by an HP). A dummy captures the start of a crisis.</td>
<td>Average effect is 1.5-2 percentage points Loss of about 4 percentage points for severe crises.</td>
</tr>
<tr>
<td>Haltmaier (2012)</td>
<td>40 developed and emerging-market economies</td>
<td>Trend production per capita (using an HP filter)</td>
<td>Growth rate decreases on average by 0.5 percentage point two years after the peak, half of this loss is recovered in the years that followed. Growth rate increases in 5 emerging Asia countries (including China) after the through of the recession but not enough to offset the initial loss. The cumulated loss is estimated to 1.5 percentage points 4 years after the peak. This loss is bigger for developed countries than for emerging-market economies.</td>
</tr>
<tr>
<td>Source</td>
<td>Region</td>
<td>Method/Approach</td>
<td>Findings</td>
</tr>
<tr>
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<tr>
<td>Hall (2014)</td>
<td>United States</td>
<td>Use of a counterfactual: the post-crisis shortfall is the difference between the 1990-2007 trend and actual data</td>
<td>From the end of 2007 to 2013, American output fell by a cumulative 13.3% below pre-crisis trend, with most of the shortfall occurring before the end of 2010. The biggest contributors were a shortfall in business capital and in TFP.</td>
</tr>
<tr>
<td>Haugh et al. (2009)</td>
<td>OECD countries</td>
<td>Qualitative analysis</td>
<td>Japan is the only country for which a banking crisis would have a persistent impact on potential growth.</td>
</tr>
<tr>
<td>Howard et al. (2011)</td>
<td>Trend production (Hodrick Prescott)</td>
<td>Long and severe recessions lead to a permanent loss from 8 to 10% after 10 years.</td>
<td></td>
</tr>
<tr>
<td>Hoggard, Reis and Sapporta (2002)</td>
<td>Developed and emerging-market economies</td>
<td>Comparison of production to trend</td>
<td>Cumulated losses are higher for OECD countries (23.8% of GDP) than for emerging-market economies (13.9% of GDP).</td>
</tr>
<tr>
<td>Hoggard, Reis and Sapporta (2002)</td>
<td>Developed and emerging-market economies</td>
<td>Comparison crisis episodes with similar countries without banking crisis</td>
<td>Recession with a banking crisis leads to a loss of 32% of GDP as compared to 6% without crisis for developed countries (16% and 6% for emerging economies).</td>
</tr>
<tr>
<td>Hutchison and Noy (2002)</td>
<td>24 emerging-market economies</td>
<td>Estimation with a dummy exchange-rate crises (banking crises) are associated with an average decrease of GDP of about 5-8 (8-10) points after 2-3 years.</td>
<td></td>
</tr>
<tr>
<td>INSEE (2010)</td>
<td>OECD countries</td>
<td>GDP Test and improves the Cerra and Saxera’s approach</td>
<td>Permanent GDP losses are found but the scenario of decline in growth rates is rejected.</td>
</tr>
<tr>
<td>Kapp and Vega (2012)</td>
<td>170 countries</td>
<td>Loss distribution approach (LDA) utilisant Laeven et Valencia dummy (3 types de crises)</td>
<td>Average loss ranges between 9 to 15% of initial GDP, using comparison with pre-crisis trend or HP. Using LDA approach, worldwide costs of financial crises within periods of 5 years are in the range of 0.52 to 0.81% of 2005 world GDP. Extreme crises episodes (occurring with a one per cent probability) can lead to losses between 2.95% and 4.45%.</td>
</tr>
<tr>
<td>Koopman and Szekely (2009)</td>
<td>European countries</td>
<td>Quest simulation</td>
<td>The 2008 crisis is estimated to lead to a GDP loss of 5%</td>
</tr>
<tr>
<td>Ollivaud and Turner (2014)</td>
<td>19 OECD countries</td>
<td>counter-factual assuming a continuation of pre-crisis productivity trends and a trend employment rate which is sensitive to demographic trends.</td>
<td>Among the 19 OECD countries which experienced a banking crisis over the period 2007-11, the median loss in potential output in 2014 is estimated to be 3¾ %, compared to 2¾ % among all OECD countries.</td>
</tr>
<tr>
<td>Reinhart and Rogoff (2009)</td>
<td>OECD countries and a few emerging-market economies</td>
<td>GDP per capita Comparison to the peak</td>
<td>Banking crises are followed by a recession that lasts on average 2 years and leads to a cumulated loss of GDP per capita. Production would decline from peak to through on average by 9%.</td>
</tr>
</tbody>
</table>
ANNEX 2: PROBIT TEST ON CRISIS EXOGENEITY

The potential endogeneity of financial crises is a critical issue and should be corrected for when assessing the impact of the crisis. Indeed, it could be argued that at least on some occasions, structural economic weaknesses as reflected by low contemporaneous and past values of potential output have favoured the occurrence of crises. The exogeneity assumption of financial crisis, under which the OLS-based estimates presented above will be unbiased, thus needs to be empirically tested. This is done by estimating a probit model which expresses the probability of a crisis occurrence as a function of past potential output growth rates:

\[
\text{Prob}(D_{it} = 1) = F\left(\text{constant} + \sum_{j=1}^{4} \beta j g_{i,t-j} + \sum_{j=1}^{4} \delta j D_{i,t-j} + \omega_{it}\right)
\]  \hspace{1cm} (2)

The equation has been estimated over several periods: 1982-2012; 1982-2006 and 1990-2012. The results reported in Table 1 suggest that lagged potential GDP growth rates (as well as lagged financial crises) do not explain the occurrence of financial crises. The assumption of exogeneity of the financial crisis dummy to potential output growth rates thus appears to be valid. Those results are robust to a change in the estimation period.

| Table 1. Probit model of the effect of past growth on the probability of financial crisis |
|-------------------------------|----------------|----------------|----------------|----------------|
| Potential growth (-1)            | -0.07          | -0.33          | -0.39          | -0.44          |
|                               | (-0.85)        | (-1.72)        | (-1.37)        | (-1.5)         |
| Potential growth (-2)            | -              | 0.22           | 0.34           | 0.55           |
|                               | (1.04)         | (0.57)         | (0.9)          |
| Potential growth (-3)            | -              | -0.06          | -0.34          |
|                               | (-0.18)        | (-0.86)        |
| Potential growth (-4)            | -              |                | 0.12           |
|                               |                |                | (0.58)         |
| Number of observations          | 743            | 709            | 675            | 641            |

Note: Z- statistics in parenthesis
ANNEX 3: SIMULATION RESULTS

Baseline model

Direct crisis impact on potential output
% of potential output, 1% confidence band

model with hysteresis

model without trend

mode without hysteresis (without trend)

model excl. Turkey, Mexico and Korea
Model with interaction term between hysteresis and crisis

Direct crisis impact on potential output
% of potential output, 1% confidence band

- Model with hysteresis
- Model without trend
- Model without hysteresis (without trend)
- Model excl. Turkey, Mexico and Korea
Hysteresis coefficient
% of potential output, 1% confidence band
model with hysteresis
model without trend
model excl. Turkey, Mexico and Korea

Interaction hysteresis and crisis
% of potential output, 1% confidence band
model with hysteresis
model without trend
model excl. Turkey, Mexico and Korea

- 31 -
Constant break
1% confidence band

- model with hysteresis
- modele without hysteresis (without trend)
- model without trend
- model excl. Turkey, Mexico and Korea