Received: 29 December 2016 | Revised: 27 October 2019 | Accepted: 24 March 2020

DOI: 10.1111/boer.12241

BULLETIN OF ECONOMIC RESEARCH

ARTICLE

Recessions and potential GDP: The case of Mexico

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The opinions in this paper are the authors' own and do not necessarily reflect the point of view of Banco de México.

Abstract

There is growing evidence that deep recessions may have a permanent and negative impact on both the level and growth rate of the actual and potential GDP of developed economies in the medium and long term. We study the growth rate of the potential GDP of Mexico, a middle-income economy, using a modified version of the methodology proposed by Ball (2014) that employs robust time-series techniques to identify shifts and accounts for a diminishing growth rate caused by secular forces rather than crises. We find evidence in favour of the growth rate's being stable around a changing mean. On the one hand, the 1982 debt crisis and 2000 recession coincide with structural changes in the Mexican economy that had a lasting impact (on growth) and permanently lowered potential GDP levels, i.e., strong evidence in favour of the hysteresis hypothesis. On the other, we find no significant damaging effect (on potential GDP) of either the 1995 financial crisis or the Great Recession.

KEYWORDS
deep recession, growth rate, hysteresis, Mexico, potential GDP

JEL CLASSIFICATION
C32, E32, O47

1 | INTRODUCTION

The slow recovery experienced by many economies following the Great Recession of 2008 has raised concerns over the possible permanent and negative impact these events may have on potential output. The growth rates of the actual and potential output of advanced economies are lower than before the financial crisis (see Ball, 2014). This observation has led economists and policymakers alike to revisit the *hysteresis hypothesis* and reconsider the validity of the *natural-rate hypothesis* (e.g., Ball, 2014; Blanchard, 2018; Cerra & Saxena, 2008; Farmer, 2013). The first states that recessions may have a permanent impact on the level of output relative to trend (see Ball, 2014; Blanchard, Cerutti, & Summers, 2015), while the second states that fluctuations in aggregate demand (resulting from either monetary policy or other causes) affect the unemployment rate only in the short run and leave its natural level unaltered (see Friedman, 1968). The natural-rate hypothesis originally referred to the unemployment rate, but can be redefined in terms of output (see Blanchard, 2018).

As noted by Blanchard (2018), the concept of hysteresis largely disappeared following the Great Moderation that took place from the mid-1980s to around 2007, just prior to the Great Recession; it dates back to the 1980s (see Blanchard & Summers, 1986) and was the result of an attempt to explain why the natural rate of unemployment seemed to rise following every European recession of that decade. The explanation offered for the increase was that changes in the natural rate can be time dependent. The empirical literature that emerged from this concept studies hysteresis in unemployment by using unit-root tests (see Cross, 1995): rejection of the unit-root hypothesis is considered evidence against hysteresis. In terms of output, the latter can be stated as follows: potential output is influenced by the path of actual output. When output rises (falls) above (below) potential output for instance, mechanisms exist that drive potential output upward (downward). Since aggregate demand influences output, hysteresis means that demand also influences potential output.

The dynamic process of potential output is of particular relevance to Mexico, where, for the past 18 years, growth has remained stagnant at an average annual rate of 2 per cent. The Mexican economy reached its highest annual growth rate in its modern history between 1978 and 1981 (8.4 per cent on average), but following the 1982 debt crisis, its annual GDP growth rate remained barely above zero until 1988 (i.e., 0.3 per cent on average). Other recessions in 1985 and 1987 prevented the economy from achieving a rapid recovery. Bergoeing, Kehoe, Kehoe, and Soto (2002) note that for Mexico (and for many other Latin American countries), the 1980s were a lost decade. After 1988, the Mexican economy started to recover following an intense period of structural reforms. However, the financial crisis of 1995 (the most severe economic crisis in Mexico's recent history) dealt another major blow to the economy and real GDP fell by 11 per cent in just three quarters. Following this crisis, Mexico experienced a period of recovery, eventually achieving an average annual growth rate of 3 per cent in the 1990s. However, since the 2000 recession, the Mexican economy has been growing at an average annual rate of 2 per cent, with its current growth rate similar to those that prevailed prior to the Great Recession. In other words, the growth of the Mexican economy over the last two decades has remained low compared to the growth rate that prevailed before the 1982 debt crisis.

The aim of this study is to examine whether recessions can explain Mexico's low potential GDP growth in recent decades and to provide further empirical evidence of the hysteresis hypothesis by using robust time-series techniques. To this end, we focus on the statistical properties of the growth rate of potential GDP over the period 1960Q1 to 2017Q4. Our empirical findings support the hysteresis hypothesis (potential GDP is difference-stationary around a changing mean) and suggest that the 1982 debt crisis and 2000 recession should be considered moments when the Mexican economy suffered persistent structural changes that permanently lowered the level of potential GDP, i.e., hysteresis. It is interesting to note that most empirical works on hysteresis concentrate on non-rejection of the null hypothesis as being evidence of hysteresis (see, *inter alia*, Akdoğan, 2017; Bahmani-Oskooee, Chang, & Ranjbar, 2018; Furuoka, 2017; García-Cintado, Romero-Ávila, & Usabiaga, 2015). A notable exception can be found in Meng, Strazicich, and Lee (2017), who affirm that deterministic shifts in an otherwise stationary process should also be considered evidence of hysteresis (the structuralist hypothesis).

Following Ball (2014), we estimate the impact of recessions on potential GDP by comparing actual potential GDP and the potential GDP that would have been reached had the economy not suffered a recession. That being said, Ball's procedure to quantify the impact of recessions on potential GDP entails a non-trivial issue: it does not rule out the possibility that a secular force such as diminishing returns or diminishing population growth rate may have driven the decline in the trend. In other words, the trend might decline for reasons of concavity, rather than as a result of a recession. We therefore modify the latter procedure slightly by allowing the extrapolated growth rate of potential GDP in the counterfactual situation (of no crisis) to diminish by setting different rates of decline.[1] Irrespective of the diminishing growth rate used, we consistently find that the 1980s debt crisis had a persistent negative impact on the level of potential GDP, which–partially–explains the low economic growth of the ensuing years.

This paper is organized as follows: section 2 presents a brief review of the literature on recessions and their impact on potential GDP. Section 3 describes the empirical methodology. The results are discussed in section 4 and concluding remarks appear in section 5.

2 | LITERATURE REVIEW

Do crises have a permanent negative impact on the level of GDP and on its long-term growth rate? Cerra and Saxena (2008) address this question by studying the behavior of actual GDP following financial and political crises in a sample of 190 countries for which they construct qualitative indicators of financial crises and policies. Using estimated impulse-response functions, the authors show that less than 1 per cent of deeper GDP losses are recovered over a period of 10 years. Economic contractions are thus not counterbalanced by accelerated recovery, cause a loss in output, and lead to lower growth rates in the long term. Following a similar approach, Furceri and Mourougane (2012) find, for a panel of 30 OECD countries, that a financial crisis negatively and permanently affects potential GDP, reducing it by around 1.5 per cent to 2.4 per cent on average, and that the magnitude of the effect increases with the severity of the crisis.

Haltmaier (2012) also examines whether the growth of potential output is affected by recessions. She uses a sample of 40 countries (i.e., 21 advanced economies and 19 emerging) and finds, through panel regressions, that in advanced economies the depth of a recession has a significant impact on the loss of potential GDP, whereas in emerging economies, the length of a recession is important. Haltmaier concludes that the Great Recession may have resulted in average declines in trend potential output growth of around 3 per cent in advanced economies, but had little impact on the trend growth of emerging ones. Similar results are found in a document published by the European Commission (2009), which shows that the financial crisis caused a significant reduction in potential GDP growth rates in the short term of between 0.7 per cent and 0.8 per cent in countries of the European Union, which would result in a cumulative loss of potential GDP of around 3 per cent in 2013. Ball (2014)'s estimates are even higher; by comparing current estimates of potential GDP in 2015 to the path that

[1] This approach is similar to that proposed by Blanchard (2018).

potential GDP was following prior to the Great Recession in 23 OECD countries, he finds an average loss of potential GDP, weighted by economy size, of 8.4 per cent and concludes that most countries in his sample have experienced strong hysteresis effects.

The aforementioned empirical studies actually show that recessions may have a permanent impact through hysteresis effects. The channels through which the negative effects of recessions are transmitted to potential GDP and its growth rate are discussed in Furceri and Mourougane (2012), Haltmaier (2012), and Ball (2014), these being: (i) Via a negative impact on investment, which can lead to lower capital accumulation and, in turn, to lower potential GDP; (ii) Via a negative impact on the level and growth rate of total factor productivity (or TFP), which may occur if there is slow industrial restructuring as a result of credit constraints or structural rigidities that favor the use of resources in relatively unproductive activities; (iii) Via the impact on TFP that may result from lower investment in research and development; (iv) Via the reduction, in the case of long, deep recessions, in the potential labour force that may result from discouraged workers retiring, as well as the permanent destruction of human capital that may result from prolonged unemployment.

3 | EMPIRICAL STRATEGY

In this section, we present the methodologies we employ to estimate potential GDP. We then describe the time-series analysis we use to empirically study hysteresis, and finally we comment on the strategy we use to measure the impact of recessions on the level of potential GDP.

3.1 | Estimating potential output

Potential GDP provides a benchmark for identifying what phase of the cycle (recession or expansion) economic activity is in and is therefore useful to deduce whether the implementation of a policy will be pro-cyclical or counter-cyclical. However, measuring potential GDP is a challenging task because it cannot be directly observed and must therefore be inferred from the data. ——————— There is a wide variety of methodologies to estimate potential GDP.[2] In this paper, we choose two: (i) the SAVN filter (which is a modified version of the HP filter proposed by St-Amant & van Norden, 1997), and (ii) the Production Function methodology. The first is a univariate filter and requires the use of the real GDP series only. In this regard, one drawback of this methodology is that it ignores the structural relationships between fundamental macro variables. In order to deal with this issue somewhat and to study the robustness of our results, we resort to the Production Function methodology to estimate potential GDP. The two methodologies are explained below.

The St-Amant and van Norden (SAVN) filter: The Hodrick and Prescott (1997) (HP) filter decomposes a time series y_t (previously seasonally adjusted) into cyclical and trend components, c_t and g_t, respectively. The trend component is determined by minimizing the variability of the cyclical component subject to a penalty on variations of the second difference of the trend component (in other words, the changes suffered by the slope of the trend). The variability in the trend component is penalized by a smoothing parameter, $\lambda > 0$. For quarterly data, Hodrick and Prescott suggest $\lambda = 1600$.

The HP filter has two main drawbacks: (i) the need to select an appropriate value of λ for a given economy and, (ii) the amount of invalid points at the sample tails. As for the first issue, Marcet and

[2]Cerra and Saxena (2000), for instance, obtain estimates of the potential GDP of Sweden by using seven different methods and list the advantages and disadvantages ofeach.

Ravn (2004) propose an algorithm to estimate the parameter λ endogenously. As for the second, St-Amant and van Norden (1997) propose a modified HP filter that penalizes the fact that the trend shows a relatively stronger reaction to transitory shocks in more recent sample data. The SAVN minimization problem can be expressed as

$$\min_{\{g_t\}_{t=1}^{T}} \sum_{t=1}^{T}(y_t - g_t)^2 + \lambda \sum_{t=1}^{T}[(g_t - g_{t-1}) - (g_{t-1} - g_{t-2})]^2 + \lambda_{ss} \sum_{t=T-j}^{T} (\Delta g_t - u_{ss}). \tag{1}$$

The first two terms of equation (1) are identical to those of the HP filter. The SAVN filter also includes a third term, $\lambda_{ss} \sum_{t=T-j}^{T}(\Delta g_t - u_{ss})$, whose function is to smooth the trend in the last j periods of the sample, where u_{uss} is a constant equal to the long-term growth rate of the series and $\lambda_{ss} \geq 0$ is the penalty applied to deviations of the growth rate from the long-term trend.[3]

The Production Function methodology: Unlike the previous methodology that makes statistical assumptions on the time-series properties of trends, the Production Function (hereafter PF) approach is fully supported by economic theory. Of course, it requires assumptions concerning the functional form of the production function, TFP, the representative use of production factors, and returns to scale (see Giorno, Richardson, Roseveare, & van den Noord, 1995; De Masi, 1997; Havik et al., 2014). We assume a Cobb-Douglas PF with constant returns to scale, where GDP (Y_t) is a combination of factor inputs: labour (L_t), capital stock (K_t) corrected for capacity utilization (v_t), and adjusted for TFP (A_t), according to:

$$Y_t = A_t(K_t v_t)^{\alpha} L_t^{1-\alpha}, \tag{2}$$

where α represents the output elasticity of capital. Estimating potential GDP requires removing the cyclical component from TFP, capacity utilization, and labour. Note that the capital stock series does not need to be detrended, as the series itself represents its potential level.[4]

3.2 | A time-series analysis for hysteresis

From an econometric perspective, the hysteresis hypothesis has been studied using a unit-root test on the unemployment rate (see Cross, 1995): random shocks permanently affect a unit-root process, but only transiently to a stationary process (of course, this view also applies to actual and potential GDP levels). A caveat of this approach is that shifts in the levels of such variables are not necessarily attributable to recessions. Therefore, we assume instead that unit roots are not the only data-generating process that provides evidence in favor of the hysteresis hypothesis; a stationary process around a changing mean in actual and potential GDP differences should also be considered evidence of hysteresis, especially when the shift coincides with a recession (this interpretation of the phenomenon can also be found in Meng et al., 2017). To be precise, a shifting-mean process better corresponds to the hysteresis definition than the infinite-memory unit-root process does.

Thus, to assess whether recessions have produced important shifts along the potential GDP level, we propose an alternative approach, one also based on time-series techniques, in which particular attention is paid to the statistical properties of the growth rate of potential GDP. We employ the test proposed by Kapetanios (2005), which is robust to structural breaks, to draw inference about a possible unit root in

[3]For Mexican data, Antón (2010) shows that the SAVN filter substantially reduces the estimate issue inherent to the HP filter at the sampletails.

[4]See Appendix A for specific details on thismethodology.

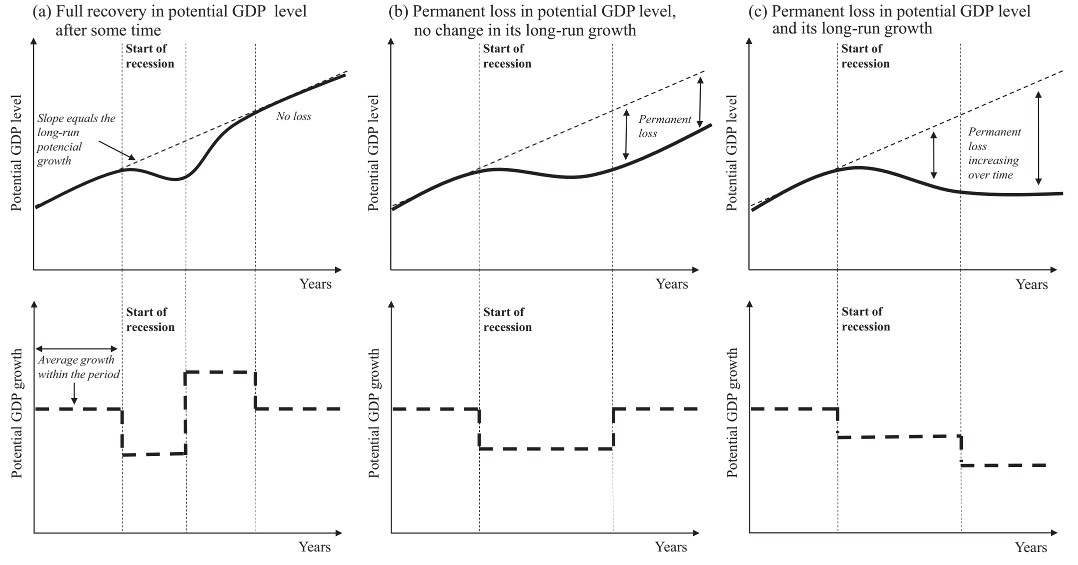

FIGURE 1 Possible effects of recessions on Potential GDP
Source: European Commission.

the series, and the Bai and Perron (1998, 2003) procedure, specifically designed to estimate structural breaks in stationary time series.[5]

To clarify our methodology, in Figure 1 we show that the impact of a recession on potential GDP *a priori* could take three possible forms, as discussed in the European Commission (2009) document:

(a) *Full recovery in potential GDP level. In this case, potential growth accelerates such that the economy returns to its pre-crisis trend. Under this scenario, there is no empirical evidence of hysteresis.*
(b) *Permanent loss in potential GDP level, no change in its long-run growth. Eventually potential growth returns to its pre-crisis rate. Under this scenario, there is empirical evidence of hysteresis.*
(c) *Permanent loss of potential GDP level and decline in its long-run growth. In this case, potential growth never returns to its pre-crisis rate. Under this scenario, there is empirical evidence of hysteresis and even super-hysteresis, a term used by by Ball (2014) and Blanchard et al. (2015) to describe the impact of a recession on both the level and growth rate of potential GDP.*

Hence, our criteria for determining whether a recession caused hysteresis is twofold: we consider there to be evidence of hysteresis when (i) a structural break coincides with the beginning of a recession, and: (ii) the growth rate of potential GDP follows a similar pattern to that shown in panels (b) and (c) of Figure 1.[6]

[5]Though structural breaks play a key role in empirical macroeconomics, their use in identifying the recession and expansion periods that produced important shifts in actual and potential GDP series is not, to the best of our knowledge, a standardprocedure.

[6]Note that it is possible to map structural breaks (shifts) in the growth rate of potential GDP against shifts in the levels of the variable and relate these torecessions.

3.3 | Measuring the impact of recessions

To quantify the damage caused to potential GDP by recessions, we follow Ball (2014)'s methodology. For a specific country, the latter author takes the log annual real GDP series (denoted by y) and potential GDP series (denoted by y^*), then estimates the level that potential GDP would have reached (denoted by y^{**}) if the Great Recession had never occurred. Noting that the change in y^* is almost constant from 2000 to 2009, Ball takes the pre-crisis data as estimates of y^{**} and extends the series beyond 2009 via a log-linear extrapolation. He computes the average annual change in y^{**} from 2000 to 2009 and assumes the change in y^{**} remains constant at that level from 2009 to 2015. Finally, Ball computes the percentage differences between y^* and y^{**} in 2015 to assess the damage caused by the Great Recession on potential GDP. In our study of the case of Mexico, this procedure is extended to each of the recessions that coincide with the break dates found using the Bai-Perron procedure. As for the log-linear extrapolation, there is a non-trivial caveat. In the words of Blanchard (2018):

> *"One delicate empirical issue is that output growth has declined in most advanced countries over the sample period; thus, the extrapolation of a log-linear trend over any pre-recession time interval will tend to overpredict post-recession output and lead to an estimated negative output gap, even in the absence of any hysteresis."*

Though Mexico cannot yet be considered an advanced country, its output growth rate may also have diminished due to secular forces, and our measurement of the impact of recession could also be overestimated.[7] We therefore also extend the reach of Ball's methodology by assuming linear and quadratic diminishing rates of growth to extend the series of potential GDP beyond the recessions. Our approach closely resembles that proposed by Blanchard (2018).[8]

3.4 | Data

The seasonally adjusted quarterly series of GDP at constant prices spanning the period 1960Q1 to 2017Q4 for Mexico was obtained from FRED.[9] It is important to emphasize that, to the best of our knowledge, this time-series has not been chained; moreover, the identified break dates do not correspond to known methodological changes carried out by the Mexican Statistical Office (INEGI).[10] The potential GDP series was obtained by applying the SAVN filter to the log level of the real GDP series.[11] The details of how potential GDP is constructed using the PF methodology are given in Appendix A. The final series spans a shorter period, 1987Q1-2017Q4, given the limited availability of the factor inputs series required by this methodology.

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[7] We would like to thank an anonymous referee for bringing this possibility to ourattention.

[8] See Blanchard (2018)'s onlineappendix.

[9] Mexico's original series can be retrieved from FRED (Federal Reserve Bank of St. Louis). The original source of the series is the OECD (1960 to 2014); we updated this series, based on information from INEGI (Mexico's Office of Statistics). It is worth noting that no chaining is necessary, as the overlapping period from the two sources isidentical.

[10] According to INEGI, such changes correspond to the National Account Systems approved by the United Nations Statistical Office in 1968, 1993, 2008, and recently in2013.

[11] We follow the algorithm of Marcet and Ravn (2004) and set $\lambda = \lambda_{ss} = 2015$ for the study period. We use $u_{ss} = 2.7$ per cent and $j = 7$.

TABLE 1 Recession episodes in Mexico (1960Q1-2017Q4)

Peaks	Troughs	Duration (Q)	Depth (per cent)
1981Q4	1983Q2	7	10.0
1985Q3	1986Q4	6	5.4
1987Q4	1988Q2	3	1.0
1994Q4	1995Q2	3	11.1
2000Q3	2002Q1	7	5.1
2008Q2	2009Q2	5	8.4

Note: Recessions are identified according to Harding and Pagan (2002)'s algorithm. Duration is measured in quarters from peak to trough and depth as a percentage change in GDP.

4 | RESULTS

In this section, we present the results of our empirical strategy. We identify the structural breaks in the growth rate of potential GDP and relate these to recessions. Lastly, we measure the impact of those recessions that provide evidence of hysteresis.

4.1 | Economic cycles in Mexico

We first characterize Mexico's economic cycles and define the recessions following the algorithm of turning points proposed by Harding and Pagan (2002).This methodology identifies peaks and troughs as local maxima and minima in the log level of the real GDP series (1960Q1-2017Q4).[12]

The beginning, end, duration, and depth of the recessions are reported in Table 1. Panel (a) of Figure 2 shows the log level of real GDP and the recession episodes, while panel (b) shows the output gap of Mexico estimated using (i) the SAVN filter and (ii) the PF methodology. It is worth noting that both methods provide somewhat similar results (correlation of 0.95).

Two interesting aspects of Mexico's economic cycles are evident: (i) during the 1980s, recessions occurred quite frequently (i.e., every year and a half on average);[13] and (ii) since the 1990s, recessions have occurred much less frequently (every five years on average), thus implying more prolonged expansion.

4.2 | Identification of structural breaks

We apply the Kapetanios (2005) test to the growth rate of the potential GDP series estimated using the SAVN filter and the PF methodology. By rejecting the null hypothesis of unit root, this test provides evidence of the stationarity of the series and thus makes the series a suitable candidate for the Bai and Perron (1998, 2003) (hereafter BP) testing procedure.[14]

[12]This algorithm has the advantage that the results are independent of the technique for extracting the trend component from the real GDP series. The algorithm requires that: (i) complete cycles run from peak to peak and have two phases (contraction, from peak to trough, and expansion, from trough to peak), and (ii) the minimum duration of a complete cycle is at least $c = 5$ quarters, with each phase lasting at least $p = 2$quarters.

[13]This is why we quantify the effects of the 1980s recessions as a whole, rather than analysing each separately (see Section4.3). As documented by Cerra and Saxena (2008), recovery after a deep recession is not immediate. Therefore, the analysis of the 1982 recession in Mexico could be contaminated by that of 1985 and, in turn, the subsequent post-recession recovery could be contaminated by the recession of1987.

[14]It is important to emphasize that Bai and Perron's procedure is not valid undernonstationarity.

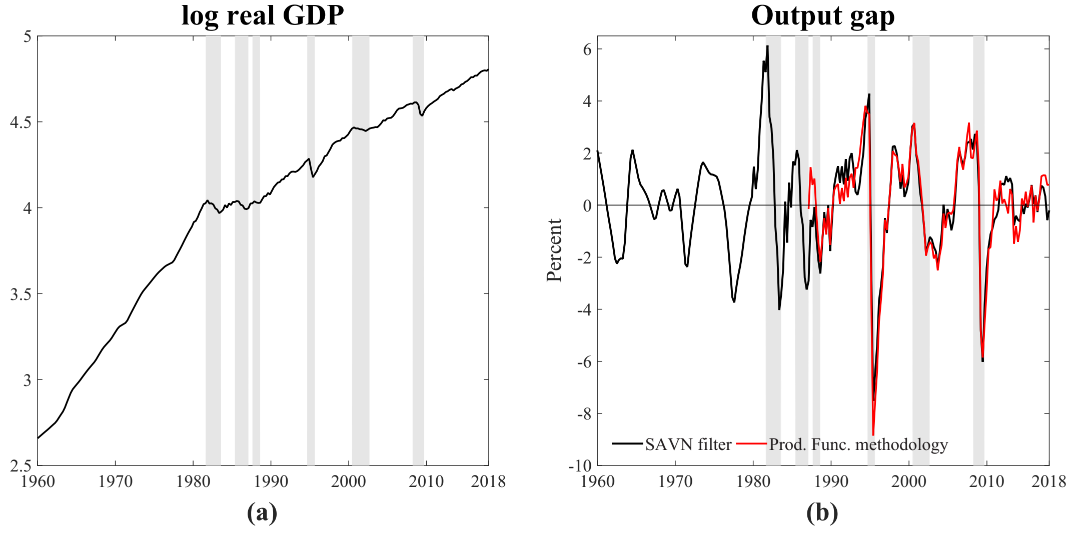

FIGURE 2 (a) Log of real GDP (1960Q1-2017Q4). (b) Output gap estimated via the SAVN filter (1960Q1-2017Q4) and the PF methodology (1987Q1-2017Q4) [Colour figure can be viewed at wileyonlinelibrary.com]
Note: Gray areas depict dates of recessions.
Source: Authors' own estimates using data from FRED and INEGI.

For both series, the null hypothesis of unit root is always rejected at the 5 per cent level, so there is sufficient evidence to support stationarity. In other words, the growth rate of potential GDP is characterized as a process that is stationary around a changing mean.[15] The relevance of this unit-root test lies in the fact that it controls for endogenously defined level breaks. A caveat of the Kapetanios test is that the number of breaks must be pre-defined by the practitioner. In this regard, the main aim of the test is to avoid losses of power by adequately controlling for breaks, rather than estimating the breaks or the break dates themselves. For this reason, we do not employ the break dates identified by Kapetanios to carry out our analysis.[16]

The stationarity evidence provided by the Kapetanios test allows us to then apply the BP procedure to estimate the number of breaks and the break dates accurately. The BP procedure, which is robust to heteroskedasticity and serial correlation, is applied to the growth rate of potential GDP. The null hypothesis of parameter stability is systematically rejected for both series at the 5 per cent level. For the series obtained from the SAVN filter, the test shows significant evidence when between 1 and 5 breaks are allowed, and in the case of 5 breaks, the test is highly significant. For our research purposes, we use the results produced by the 5 breaks found. For the series obtained using the PF methodology, the test provides significant evidence when 1 and 2 breaks are allowed, and in the case of 1 break, the test is highly significant. Nonetheless, we take the test statistic when 2 breaks are controlled for. Figure 3 shows the results of this test for the SAVN filter and Table 2 shows the estimated break dates for both series.

[15]In addition, we also performed the BP procedure on the levels of actual and potential GDP series. The auxiliary regression corresponds to the model with level shifts, where we set five breaks and a trimming of 0.10. We failed to reject the null hypothesis of unit root at the 5 per cent level. Results available uponrequest.

[16]Details of the Kapetanios test and Bai-Perron testing procedure are provided in Appendixes B and C for the series estimated using the SAVN filter and the PF methodology,respectively.

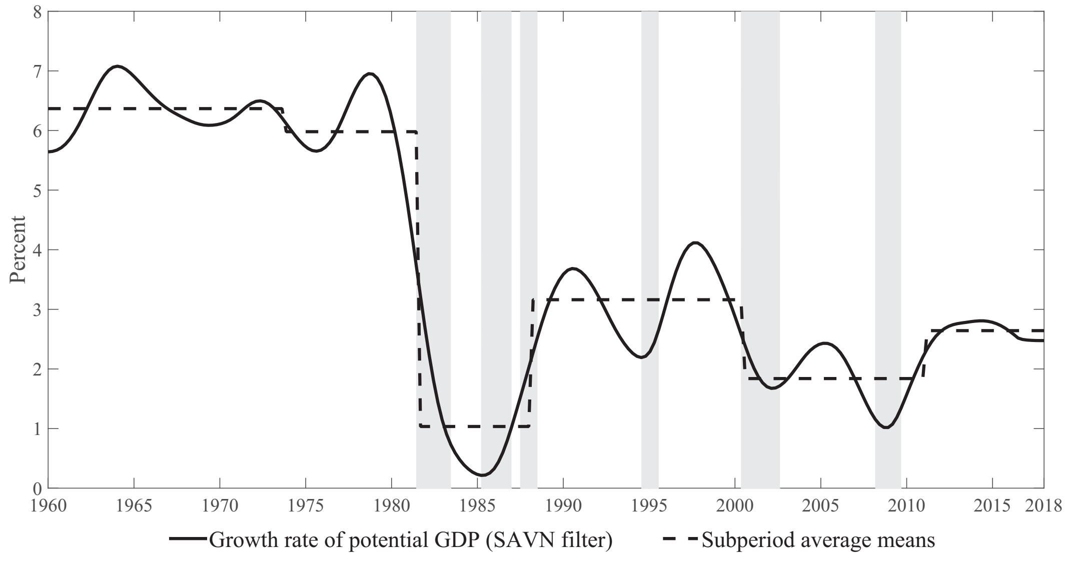

FIGURE 3 (Annualized) Growth rate of potential GDP of Mexico and average means for the subperiods defined by the breaks estimated via the Bai-Perron procedure [Colour figure can be viewed at wileyonlinelibrary.com]
Note: Gray areas depict dates of recessions.
Source: Authors' own estimates using data from FRED and INEGI.

TABLE 2 Bai-Perron testing procedure applied to the potential GDP growth rate series

Methodology	Breaks allowed	Estimated break dates
SAVN filter†	5*	1974Q1, 1981Q4, 1988Q2, 2000Q3, 2011Q1
PF‡	2*	2000Q3, 2011Q1

Note: †Sample: 1962Q2-2017Q4. ‡Sample: 1987Q2-2017Q4. *Significant at the 5 per cent level. The test is applied with a constant as a regressor. Up to five breaks are allowed; the trimming parameter is equal to 0.10. Serial correlation and different variances of residuals along the segments are also permited.

TABLE 3 Average Growth Rate of the potential GDP per subperiod

	Quarterly (per cent)		Annualized (per cent)	
Subperiod	SAVN	PF	SAVN	PF
1. 1960Q2-1973Q4	1.6	–	6.4	–
2. 1974Q1-1981Q3	1.5	–	6.0	–
3. 1981Q4-1988Q1	0.3	–	1.0	–
4. 1988Q2-2000Q2	0.8	0.8	3.2	3.2
5. 2000Q3-2010Q4	0.5	0.4	1.8	1.7
6. 2011Q1-2017Q4	0.7	0.7	2.6	2.6

Note that, irrespective of which methodology is used to estimate potential GDP, the BP procedure always finds two structural breaks: in 2000Q3 and 2011Q1, which provides robustness to our results. The quarterly and annualized average growth rates of Mexico's potential GDP in each subperiod defined by the break dates found with the BP testing procedure are shown in Table 3 and Figure 3. We include annualized growth rates, since these allow a better reading of the changes along the subperiods.

Interestingly, not all the structural breaks found via the BP procedure coincide with the beginning of one of the recessions identified earlier (see Tables 1 and 2, and Figure 3). The results from the BP procedure suggest that the 1982 debt crisis and 2000 recession reduced the growth rate of potential GDP-the former having a much major impact than the latter-and determined structural changes in Mexico's potential GDP growth rate. Therefore, according to our criteria, the effects of the 1980s and 2000 recessions have been persistent, i.e., they permanently lowered potential GDP levels, which provides strong evidence in favour of the hysteresis hypothesis. As a corollary to this interpretation, one could also argue that when a recession does not coincide with a structural break, this may be an indication that the recession in question had neither a damaging nor a significant effect on the level of potential GDP.

4.2.1 | Explaining structural breaks

The discovery of major oil reserves in the second half of the 1970s provided a boost to the country's economic growth of that time and helped the Mexican economy achieve the highest growth rate in its recent history. This event may explain the structural break in 1974Q1. The second break coincides with the beginning of the 1982 debt crisis. Mexico experienced other recessions in 1985 and 1987, and the growth rate of potential GDP remained rather low during the period 1982–88. The third structural break, found in 1988Q2, comes at the beginning of an intense period of economic reforms (trade liberalization, privatization of state enterprises, etc.), any (or all) of which could explain the change in the potential GDP growth rate, which on that occasion was considerably accelerated (see Table 3).[17]

According to our estimates, the financial crisis of 1995 and the debt crisis of 1982, in that order, were the most severe recession episodes in Mexico's recent history. However, the 1995 financial crisis does not appear to have had a damaging effect on potential GDP. In fact, when we decompose subperiod 4 (1988Q2-2000Q2) into two periods without taking into account the period of the 1995 financial crisis (1994Q4-1995Q2), we obtain an average growth rate of potential GDP for the period 1988Q2 to 1994Q3 of 0.74 per cent (from the SAVN filter) and 0.76 per cent (from the PF methodology), and 0.86 per cent (from the SAVN filter) and 0.82 per cent (from the PF methodology) for the period 1995Q3 to 2000Q2. In other words, after the 1995 financial crisis, potential GDP grew by around 16 per cent (from the SAVN filter) and 8 per cent (from the PF methodology) more than it did before the crisis. One possible explanation for this is that the financial crisis coincided with the enactment of the North American Free Trade Agreement (NAFTA) and the US economic boom of the 1990s.

Meanwhile, the attacks of 9/11 deepened the US recession of 2001, provoking a fall in US demand for Mexican products. According to our estimates, the recession experienced by Mexico in 2000 determined a structural break, since which time the economy has been growing at an annual average rate of 2 per cent. Lastly, the BP procedure does not find a structural break to match the beginning of the Great Recession around 2008–09, suggesting that that recession had no significant impact on the growth rate of Mexico's potential GDP. This may be due to the fact that the financial crisis originated in advanced industrial countries rather than in emerging ones. The last break, detected in 2011Q1, should be treated with caution: while the SAVN filter reduces the estimate issue inherent to the HP filter at the sample tails, it is sensitive to the long-run growth rate of the series and, therefore, relies heavily on growth forecasts.

[17]Needless to say, time-series analysis has its limitations, as it is usually impossible to causally link a structural break to a preciseevent.

4.3 | Measuring the impacts of recessions on potential GDP

In the preceding section, we found that the 1982 debt crisis and 2000 recession caused permanent shifts in the level and growth rate of potential GDP, whereas in this section we focus on measuring their effect on the level of potential GDP. In addition, we analyse the impact of the Great Recession as a robustness check of our corollary.

Quantifying the damage caused to the level of potential GDP by recessions entails two main issues: (i) the damage quantification is sensitive to the time period used to estimate pre- and post-recession trends, and (ii) the decline in the growth rate of potential GDP could be caused by secular forces, such as demographics or diminishing returns, which have nothing to do with recessions and could provoke an over-estimation of the damage.

As regards the first issue, we limit the length of time according to the structural-break dates estimated by the BP procedure. As regards the second, we modify Ball (2014)'s procedure slightly by allowing the extrapolated growth rate of potential GDP in the counterfactual situation of no crisis to exhibit diminishing returns and set linear and quadratic diminishing rates of decline. These rates have been selected because: (i) they can be easily interpreted as an economy that is steadily approaching its long-term (lower) equilibrium growth rate, and (ii) the growth rate of Mexico's population has been decreasing for the last half century, largely at a linear rate (see Figure D1 in Appendix D; it is important to emphasize that despite being supported by population growth, correcting for secular forces remains an assumption). Therefore, not accounting for secular forces will tend to overpredict later potential GDP in post-recession trends.

This strategy to account for the effects of secular forces has been used recently by Blanchard (2018), who regresses log GDP on linear and quadratic time trends over his whole sample. Then, for each recession and each post-recession period, he downwardly adjusts the estimated pre-recession trend by the coefficient of the quadratic term. Note that what Blanchard is implicitly assuming is that the growth rate of GDP diminishes linearly. To confirm this, let y_t denote the log GDP and t denote time. Thus, if $y_t = a + bt + ct^2$ with $b > 0$ and $c < 0$, then the growth rate, g, is given by $g = b + 2ct$. In contrast, in Ball (2014)'s procedure it is implicitly assumed that $y_t = a + bt$ and $g = b$. Therefore, q quarters after a recession, the cumulative losses in log GDP will be $cq(q + 1)$ lower under Blanchard (2018)'s procedure than under Ball (2014)'s.[18]

In our present study, assuming a linear (or quadratic) diminishing growth rate of potential GDP for the entire sample (1960Q2-2017Q4) seems inappropriate, given the important shifts that this series has experienced (see Figure 3). However, that assumption does seem reasonable in two contiguous subperiods, for instance from subperiod 2 (1974Q1-1981Q3) to subperiod 3 (1981Q4-1988Q1), where the growth rate of potential GDP falls largely at a linear rate. Unlike Blanchard (2018), who takes different time windows to estimate pre- and post-recession trends, we take advantage of structural breaks that coincide with recessions. The effects of recessions on Mexico's potential GDP are described next.

The 1980s recessions: To measure the impact of the recessions of the 1980s (1982, 1985, and 1987) on Mexico's potential GDP, we consider subperiods 2 (1974Q1-1981Q3) and 3 (1981Q4-1988Q1), estimated via the BP procedure and the results from the SAVN filter. We extrapolate log potential GDP, firstly by using an average rate of 1.5 per cent in subperiod 2 (Ball's procedure), and secondly by

[18]This comes from the fact that $2c(1 + \cdots + q) = cq(q + 1)$.

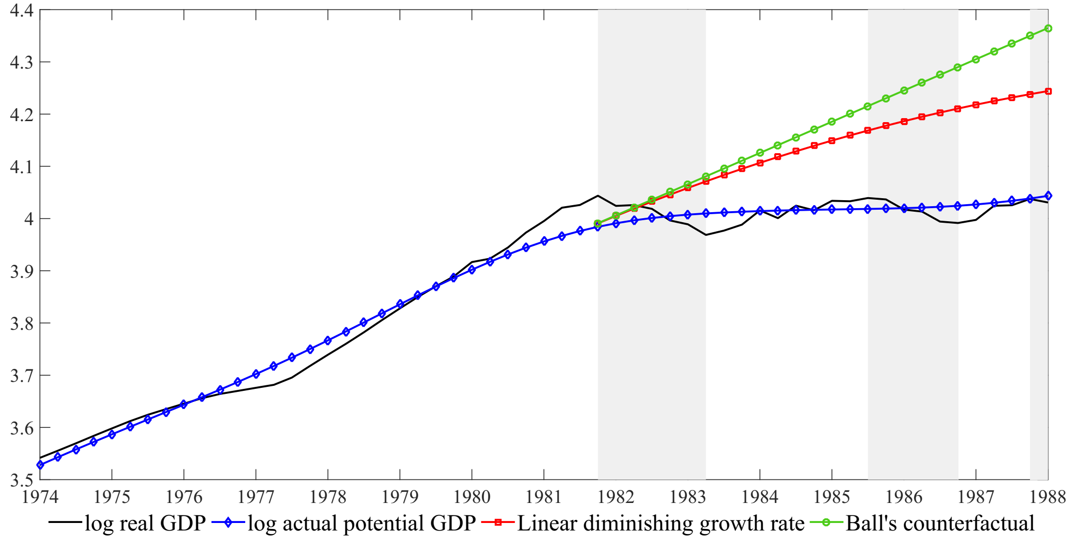

FIGURE 4 Effect of the 1980's-recessions on the potential GDP of Mexico [Colour figure can be viewed at wileyonlinelibrary.com]

Note: Gray areas depict dates of recessions.

Source: Authors' own estimates.

establishing a linear diminishing growth rate[19] of the form $g = 1.90\% - 0.03t + u_t$ along subperiod 3 (Blanchard's procedure). This is shown in Figure 4.

Let the capital letters Y, Y^*, and Y^{**} denote the series in levels of real GDP, potential GDP, and the counterfactual extrapolation, respectively, while lowercase letters denote the logarithm of these series (y, y^*, and y^{**}). From Ball's procedure, we find that in 1988Q1, the difference between y^{**} and y^* is 0.32. The difference between Y^{**} and Y^* relative to Y^{**} is 27 per cent. When we account for secular forces, we find that in 1988Q1, the difference between y^{**} and y^* is 0.20, and the difference between Y^{**} and Y^* relative to Y^{**} is 18 per cent. Note that the effect predicted in the second scenario is around 75 per cent of that predicted by Ball's procedure. These results indicate that not only did the recessions of the 1980s cause large losses in potential GDP during that decade, they also had a permanent impact on the level of potential GDP, as suggested by the structural break found in 1981Q2.

In the following two accounting exercises, we make a comparison of the estimated losses in potential GDP from the SAVN filter and from the PF methodology.

The 2000 recession: We carry out a similar exercise to measure the impact of the 2000 recession. We consider subperiods 4 (1988Q2-2000Q2) and 5 (2000Q3-2010Q4), estimated via the BP procedure. As mentioned earlier, the BP procedure does not identify a structural break at the onset of the Great Recession. Nonetheless, unlike in the preceding exercise, we shortened subperiod 5, making the cut-off point 2008Q1 in order to analyse the effects of the Great Recession separately.

We thus use the average growth rate of subperiod 4 (0.8 per cent for the SAVN filter and 0.8 per cent for the PF methodology) for Ball's counterfactual. We establish linear diminishing growth rates of the

[19]This growth rate was estimated by running a regression of the growth rate along subperiods 2 and 3 on a constant and (i) t and t^2, and (ii) t only. In the first scenario, the coefficient associated with the quadratic term is not significant at the 5 per cent level. In the second, both the constant and the coefficient of t are significant at the 5 per cent level. In this case, $2c = -0.03$.

form $g = 0.87$ per cent $- 0.005t + u_t$ and $g = 0.88$ per cent $- 0.005t + u_t$ obtained from data acquired using the SAVN filter and the PF methodology, respectively.

Ball's procedure predicts cumulative losses in 2008Q1 of around 8.80 per cent and 8.85 per cent when using the SAVN filter and the PF methodology, respectively. When we account for secular forces, we find equivalent cumulative losses of around 6.55 per cent and 6.63 per cent, respectively. Both methodologies lead to similar results in terms of cumulative losses. This result is unsurprising, as the output gap obtained from the PF methodology closely resembles the series obtained from the SAVN filter during subperiod 4 (see panel b in Figure 2).

The Great Recession: Though there was no structural break detected in 2008-09 by the BP procedure, we measure the impact of the Great Recession on Mexico's potential GDP. We limit the period of study to 2000Q3-2017Q4 and use the average growth rate for the period 2000Q3-2008Q1 (0.5 per cent for the SAVN filter and 0.5 per cent for the PF methodology) for Ball's counterfactual.

The results from the SAVN filter suggest that potential GDP returned to its pre-Great Recession trend in 2013Q1 (from Ball's procedure) and in 2012Q3 (accounting for secular forces). In contrast, the results from the PF methodology suggest that, on the one hand, there are no significant differences between Ball's counterfactual and setting a diminishing linear growth rate, and, on the other, potential GDP returned to its pre-crisis trend in 2013Q1. Moreover, both methodologies suggest that since 2013 the trend of potential GDP has been growing at a higher rate than it did pre-crisis. On average, the SAVN filter predicts a higher potential GDP growth rate than the PF methodology does (i.e., twice as high).

Results from the SAVN filter suggest that potential GDP returned to the tendency that was following prior to the Great Recession in 2013Q1 (from Ball's procedure) and in 2012Q3 (when accounting for secular forces). In contrast, results from the PF methodology suggest that, on the one hand, there are no significant differences between Ball's counterfactual and setting a diminishing linear growth rate, and in the other hand, potential GDP returned to the pre-crisis trend in 2013Q1. Moreover, both methodologies suggest that as of 2013 the trend of potential GDP has been growing at a higher rate than the pre-crisis rate. On average, the SAVN filter predicts a higher growth rate of potential GDP than the PF methodology does (more than two-times higher).

In general, both methodologies suggest that the Great Recession had no significant impact on Mexico's potential GDP. This coincides with Haltmaier (2012)'s conclusion that the Great Recession had little impact on emerging economies. Lastly, our results support the interpretation that if a structural break does not coincide with a recession date, then it had neither a damaging (as in the case of the financial crisis of 1995) nor significant impact (as in the case of the Great Recession) on potential GDP.

5 | CONCLUDING REMARKS

This paper contributes to the debate revived after the Great Recession of 2008 regarding the validity of the hysteresis hypothesis introduced by Blanchard and Summers (1986), based on the Mexican experience.

Using quarterly data from 1960Q1 to 2017Q4, we estimate the impact of recessions on Mexico's potential GDP and find strong evidence that the growth rate of Mexico's potential GDP is stable around a changing mean. The growth rate seems to have fallen after the 1982 debt crisis and 2000 recession, the effects of which have, in both cases, been persistent and permanently lowered the level of potential GDP. These findings constitute strong evidence in favor of the hysteresis hypothesis.

To quantify the impact of recessions on potential GDP, we followed Ball (2014)'s procedure, which assumes that potential GDP could have grown to its pre-crisis rate in the counterfactual situation of no crisis. Additionally, we considered diminishing growth rates in the spirit of Blanchard (2018), in order to control for secular forces that have nothing to do with a recession.

Interestingly, not all the structural breaks matched the recessions experienced by Mexico, e.g., the financial crisis in 1995 and the Great Recession in 2008. We interpret this result as an indication that such recessions did not have either significant or damaging effects on potential GDP. In fact, we found that after the 1995 financial crisis the potential GDP of Mexico grew even faster than its pre-crisis rate. Similarly, we could not find sizable effects from the Great Recession. Our estimates suggest that potential GDP growth rate returned to its pre-crisis level as of 2013. These results are robust to the use of two different methodologies for estimating the potential GDP, namely the SAVN filter and the Production Function methodology.

Interestingly, not all the structural breaks coincided with the recessions experienced by Mexico, e.g., the financial crisis of 1995 and the Great Recession of 2008. We interpret this result to be an indication that those recessions had neither a significant nor damaging impact on potential GDP. In fact, we found that after the 1995 financial crisis, Mexico's potential GDP grew even faster than its pre-crisis rate. Similarly, we found no significant impact for the Great Recession. Our estimates suggest that the growth rate of potential GDP returned to its pre-crisis level by 2013. These results are robust to the use of two different methodologies for estimating potential GDP, namely the SAVN filter and the Production Function methodology.

Lastly, while the time-series approach taken in this paper does not allow us to identify the underlying economic factors that may be behind the effects of recessions, it does suggest that some recessions can have a permanent effect on the level of potential GDP. Understanding the mechanisms of hysteresis would be a relevant agenda for future research. In sum, while there is sound evidence that Mexico suffered a slowdown in growth after certain recessions, it is impossible to establish what type of recession is more likely to entail hysteresis. A panel-data analysis involving a sizeable number of countries and a thorough study of the events affecting each could help in this regard. On the one hand, there seems to be evidence of a fundamental difference between emerging and advanced economies. On the other, while some recessions seem to be due to internal economic or financial conditions, others seem to depend on external (economic) conditions. A panel-data approach could be an adequate statistical vehicle to ascertain the conditions under which hysteresis is more likely to occur.[20]

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[20] It is important to note that, to the best of our knowledge, most panel-data empirical studies focus on unit-root testing (see Khraief, Shahbaz, Heshmati, & Azam, 2015). First- and second-generation panel unit-root tests do not control for structural breaks, a central tenet of our univariate approach. Some recent studies, such as that of Antoch, Hanousek, Horváth, Hušková, and Wang (2019), provide panel unit-root tests that control for breaks. Nonetheless, as in the univariate case (the Kapetanios test), panel unit-root tests control for breaks in order to avoid biases and/or power losses, but do not focus on either breaks or their size and location. That is why we chose to employ Bai and Perron. As far as we are aware, there is currently no panel-data econometric technique equivalent to this procedure that is as robust asBP.

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How to cite this article: Ventosa-Santaulària D, Hernández-Román LG, Amezcua AV. Recessions and potential GDP: The case of Mexico. *Bull Econ Res*. 2021;73:179–195. https://doi.org/10.1111/boer.12241