Recessions and potential GDP: The case of Mexico*

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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 favor 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 favor 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: Potential GDP, Growth Rate, Hysteresis, Deep Recessions, Mexico
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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

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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. Cerra and Saxena, 2008; Farmer, 2013; Ball, 2014; Blanchard, 2018). The first states that recessions may have a permanent impact on the level of output relative to trend (see Ball, 2014; Blanchard et al., 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 and 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%. The Mexican economy reached its highest annual growth rate in its modern history between 1978 and 1981 (8.4% on average), but following the 1982 debt crisis, its annual GDP growth rate remained barely above zero until 1988 (i.e., 0.3% on average). Other recessions in 1985 and 1987 prevented the economy from achieving a rapid recovery. Bergoeing et al. (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% in just three quarters. Following this crisis, Mexico experienced a period of recovery, eventually achieving an average annual growth rate of 3% in the 1990s. However, since the

2000 recession, the Mexican economy has been growing at an average annual rate of 2%, 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*, García-Cintado et al. (2015); Akdoğan (2017); Furuoka (2017); Bahmani-Oskooee et al. (2018)). A notable exception can be found in Meng et al. (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.

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

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% 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% to 2.4% 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% 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% and 0.8% in countries of the European Union, which would result in a cumulative loss of potential GDP of around 3% in 2013. Ball (2014)'s estimates are even higher; by comparing current estimates of potential GDP in 2015 to the path that 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% 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 labor 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 and 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

[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 of each.

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 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

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

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 et al., 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: labor (L_t), capital stock (K_t) corrected for capacity utilization (ν_t), and adjusted for TFP (A_t), according to:

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

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

where α represents the output elasticity of capital. Estimating potential GDP requires removing the cyclical component from TFP, capacity utilization, and labor. 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 the series, and the Bai and Perron (1998, 2003) procedure, specifically designed to estimate structural breaks in stationary time series.[5]

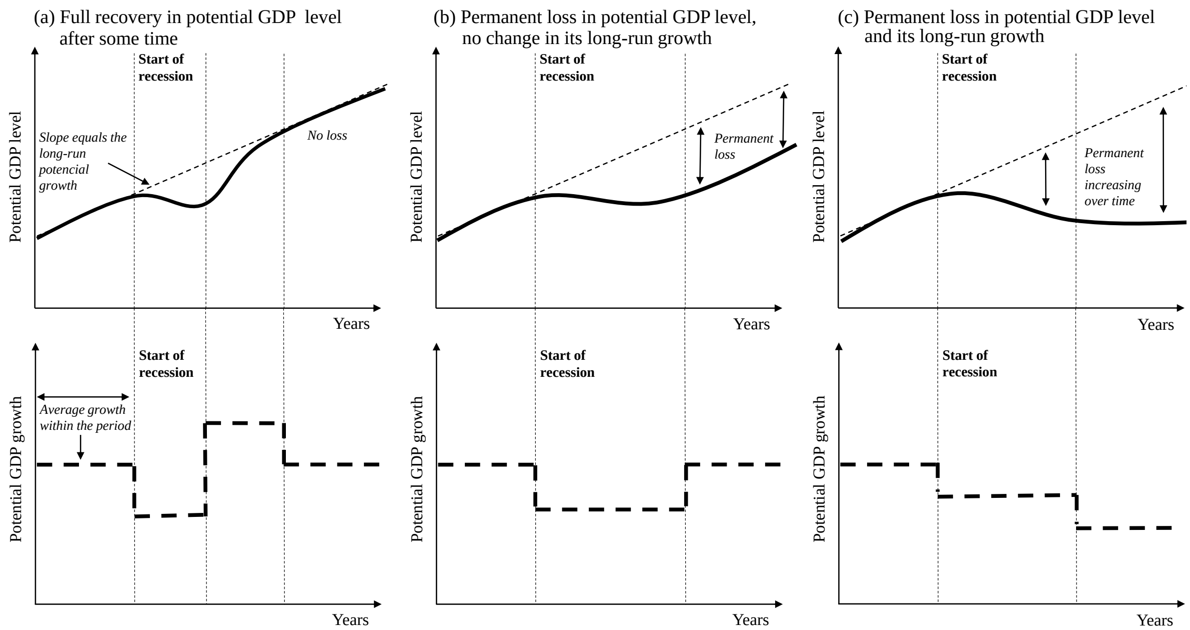
To clarify our methodology, in Figure 1 we show that the impact of a recession on potential GDP *a priori* could take three possible forms, as discussed in the European Commission (2009) document:

(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.*

[4]See Appendix A for specific details on this methodology.

[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 standard procedure.

Figure 1: Possible effects of recessions on Potential GDP



Source: European Commission

(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) *(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]

[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 to recessions.

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 over-estimated.[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

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

[8] See Blanchard (2018)'s online appendix.

[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 is identical.

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.

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).

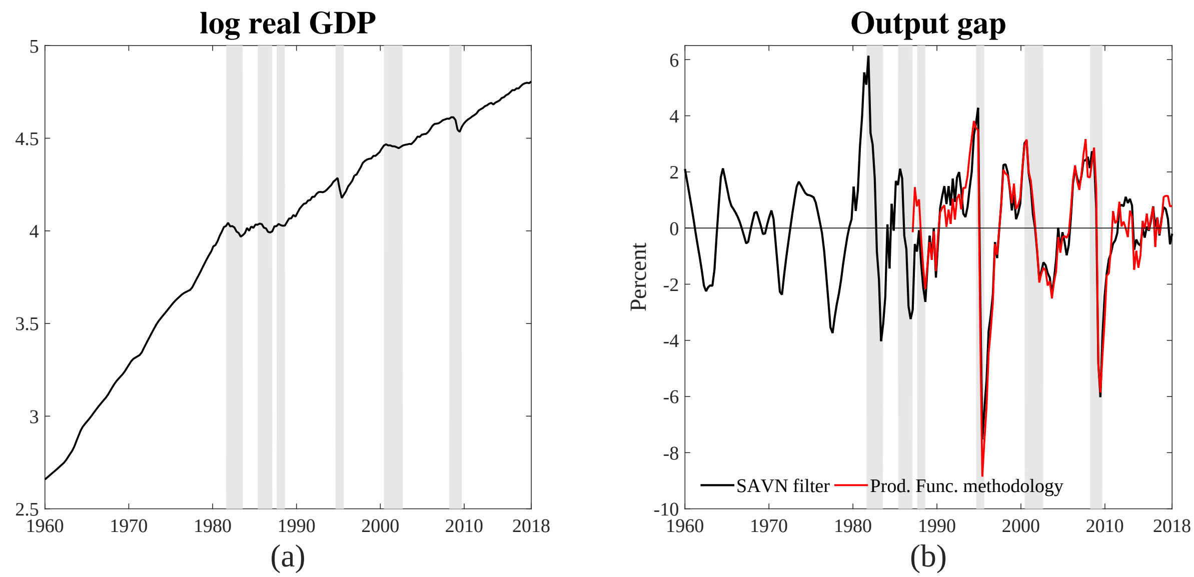
Two interesting aspects of Mexico's economic cycles are evident: (i) during the 1980s, recessions occurred quite frequently (i.e., every year and a half on average);[13] and (ii) since

[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 in 2013.

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

[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 analyzing each separately (see Section 4.3). 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 of 1987.



Gray areas depict dates of recessions. SOURCE: Authors' own estimates using data from FRED and INEGI.

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).

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]

For both series, the null hypothesis of unit root is always rejected at the 5% 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

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

[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% level. Results available upon request.

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

Peaks	Troughs	Duration (Q)	Depth (%)
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

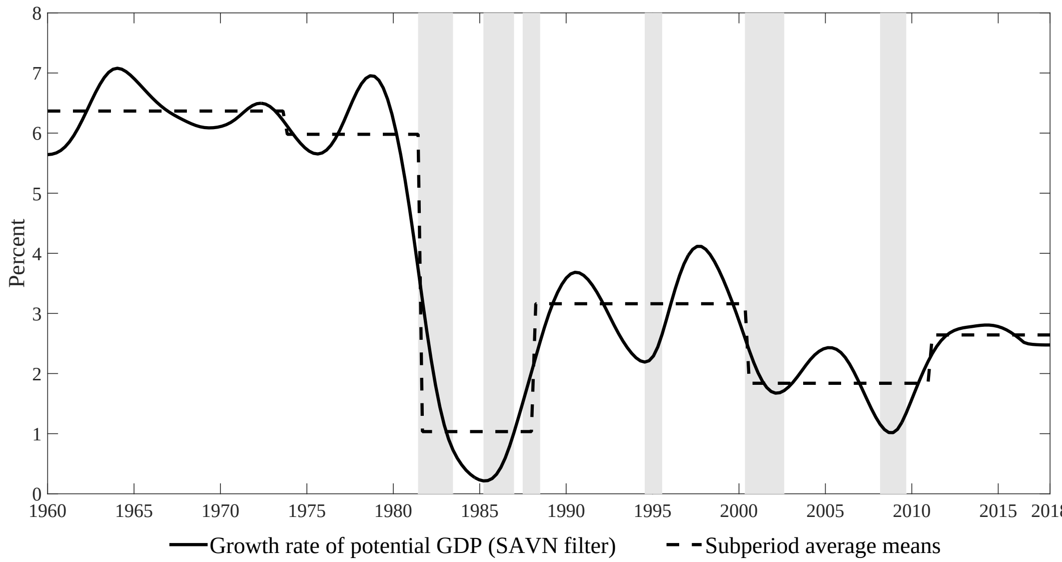
Note: Recessions are identified according to Harding and Pagan (2002)'s algorithm. Duration is measured in quarters from peak to trough and depth as a percentage change in GDP.

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% 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.

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.

[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.



Gray areas depict dates of recessions. SOURCE: Authors' own estimates using data from FRED and INEGI.

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.

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% 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.

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 favor 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 re-

Table 3: Average Growth Rate of the potential GDP per subperiod.

Subperiod	Quarterly (%)		Annualized (%)	
	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

cession 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 1982-1988. 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% (from the SAVN filter) and 0.76% (from the PF methodology), and 0.86% (from the SAVN filter) and 0.82% (from the PF methodology) for the period 1995Q3 to 2000Q2. In other words, after the 1995

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

financial crisis, potential GDP grew by around 16% (from the SAVN filter) and 8% (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%. Lastly, the BP procedure does not find a structural break to match the beginning of the Great Recession around 2008-2009, 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.

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 analyze 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.

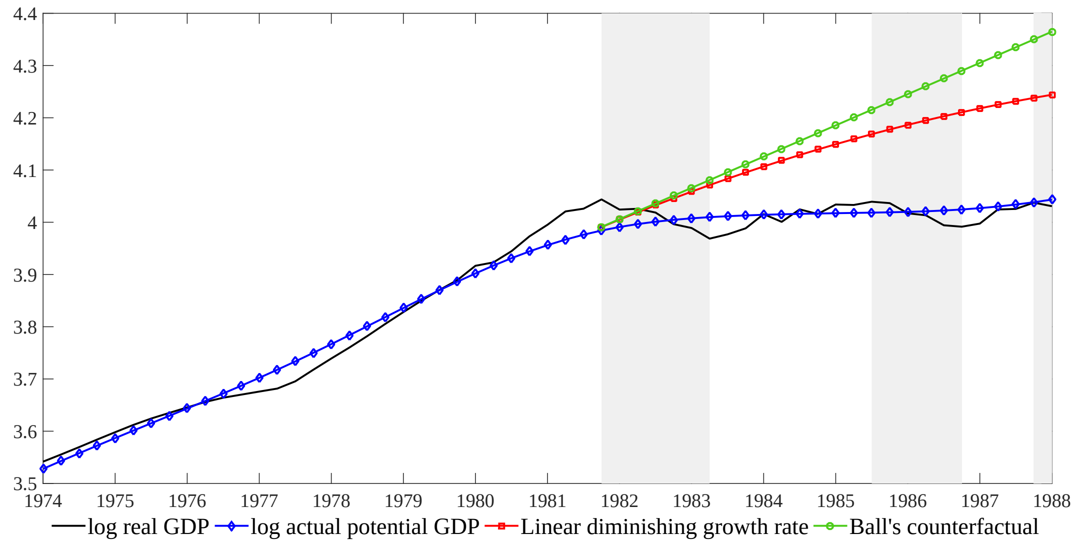
This strategy to account for the effects of secular forces has been used recently by Blanchard (2018), who regresses log GDP on linear and quadratic time trends over his whole sample. Then, for each recession and each post-recession period, he downwardly adjusts the estimated pre-recession trend by the 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% in subperiod 2 (Ball's procedure), and secondly by establishing a linear diminishing growth rate[19] of the

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

[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% level. In the second, both the constant and the coefficient of t are significant at the 5% level. In this case, $2c = -0.03$.



Gray areas depict dates of recessions. SOURCE: Authors' own estimates.

Figure 4: Effect of the 1980's-recessions on the potential GDP of Mexico.

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%. 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%. Note that the effect predicted in the second scenario is around 75% 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 analyze the effects of the Great Recession separately.

We thus use the average growth rate of subperiod 4 (0.8% for the SAVN filter and 0.8% for the PF methodology) for Ball's counterfactual. We establish linear diminishing growth rates of the form $g = 0.87\% - 0.005t + u_t$ and $g = 0.88\% - 0.005t + u_t$ 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% and 8.85% 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% and 6.63%, 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 2008-2009 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% for the SAVN filter and 0.5% 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]

[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 et al., 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 et al. (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 as BP.

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A Estimation of Potential GDP using a PF methodology

We assume a Cobb-Douglas PF with constant returns to scale, where GDP (Y_t) is represented by a combination of factor inputs: labor (L_t), capital stock (K_t) corrected for capacity utilization (ν_t), and adjusted for TFP (A_t), according to:

$$Y_t = A_t(K_t\nu_t)^{\alpha} L_t^{1-\alpha}, \tag{A1}$$

where α represents the output elasticity of capital. According to Solow (1957), the stock of capital that we must consider in a production function should be capital in use ($K_t\nu_t$), rather than capital in place. With this correction we avoid a spurious relationship between TFP and the business cycle. Estimating potential GDP requires removing the cyclical component from TFP, capacity utilization, and labor. Note that the capital stock series does not need to be detrended, as the series itself represents its potential level.[21]

Estimation of factor inputs: Given that Mexico does not have a capital stock series in quarterly frequency, this hasto be estimated. We do so by following the perpetual-inventory method given by:

$$K_{t+1} = (1-\delta)K_t + I_t, \tag{A2}$$

where I_t denotes gross investment and δ denotes the depreciation rate of physical capital. We resort to the *steady-state approach* to estimate initial capital stock, K_0.[22]

To estimate labor input series, we follow Neumeyer and Perri (2005) and define labor in terms of hours as:

$$L_t = (1-u_t)p_t h_t N_t, \tag{A3}$$

[21] For more details, see Giorno et al. (1995), De Masi (1997), and Havik et al. (2014).

[22] This approach employs neoclassical growth theory and assumes that output grows at the same rate as capital stock. It can be shown that equation (A2) in period t leads to

$$K_t = \frac{I_t}{g_K + \delta} = \frac{I_t}{g_{GDP} + \delta},$$

where g_K and g_{GDP} are capital growth and output growth, respectively. This relation is unproblematic if the economy is in fact in equilibrium. However, an economy is typically not in its long-term equilibrium. Therefore, it is more reasonable to assume that, most of the time, economies are on their adjustment path towards equilibrium. Throughout this adjustment process investment and capital accumulation tend to follow a systematic pattern and we can assume that $g_K \approx g_I$, where g_I is the investment growth rate (see de la Fuente and Doménech, 2006). Hence, an initial capital stock value can be taken as $K_0 = I_0/(g_I + \delta)$.

where u_t is the unemployment rate,[23] p_t the participation rate, h_t denotes average worked hours, and N_t the working-age population. We obtain the labor force trend by detrending u_t, p_t, and h_t. Lastly, the TFP series is estimated from the Solow residual as:

$$A_t = \frac{Y_t}{(K_t \nu_t)^{\alpha} L_t^{1-\alpha}}. \tag{A4}$$

We apply the SAVN filter to obtain the trends of labor force, TFP, and capacity utilization of capital. For this step, it is typical to apply the HP filter as discussed in Giorno et al. (1995) and De Masi (1997). Nonetheless, we prefer to use the SAVN filter to address the issues inherent in the HP filter.

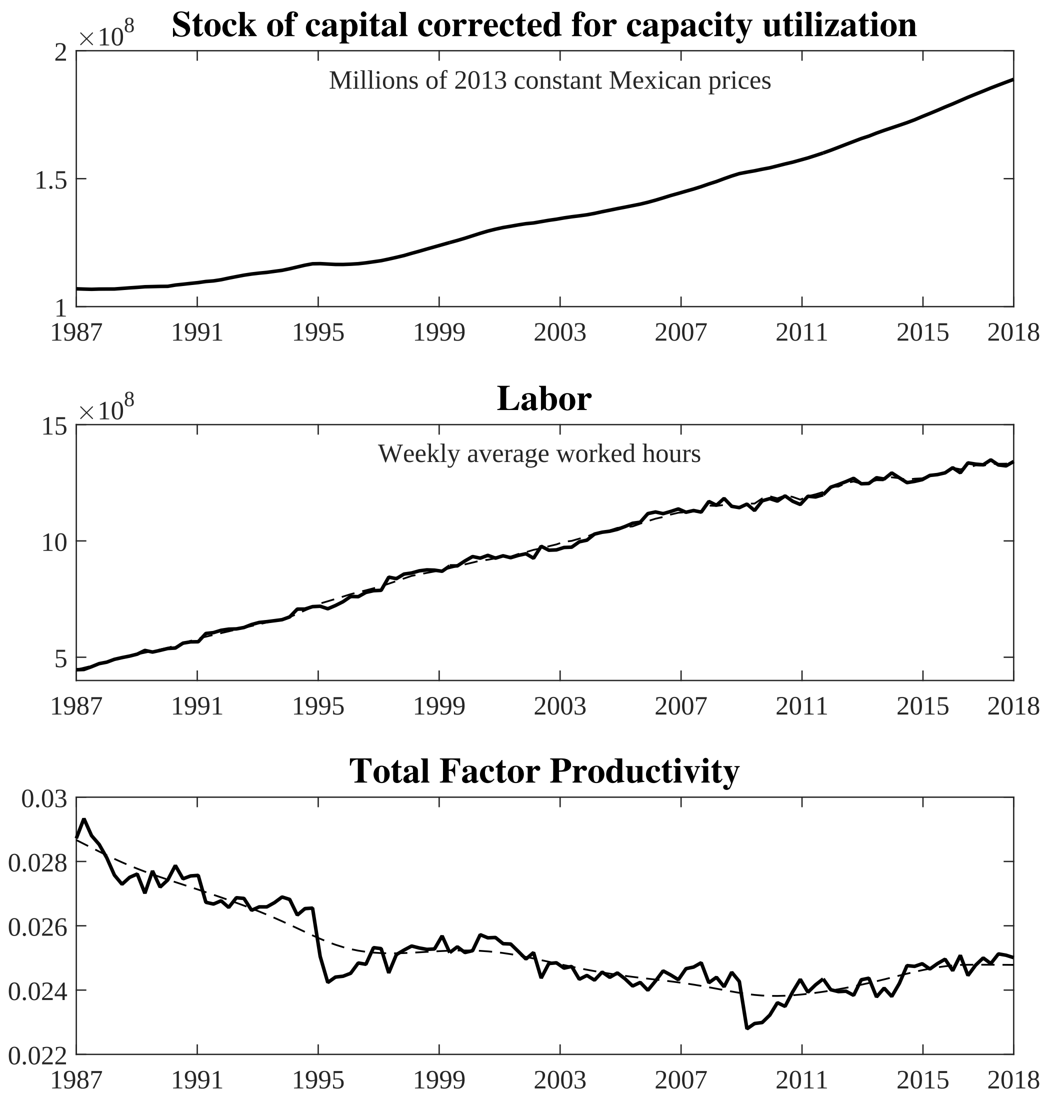
Data: We construct the potential GDP series for Mexico in quarterly frequency from 1987Q1-2017Q4. Table A1 shows the availability of each series that the PF methodology requires to estimate potential GDP. Note that the series of p_t and h_t delimit the period from 1987Q1 onwards, since these series are available from that date. Figure A1 shows the factor inputs series.

[23]We acknowledge that $(1 - u_t)$ is just an approximation. We use it because we lack a consistent series of the capacity utilization for Mexico from 1987 on. Nonetheless, as (Solow, 1957, p.314) states,"…[T]his (approximation) is undoubtedly wrong, but probably gets closer to the truth than making no correction at all."

Table A1: Data required for estimating potential GDP using the PF methodology

Variable	Availability	Details
I_t	1980Q1-2017Q4	This series is constructed as the sum of the Gross Fixed Capital Formation series plus the Changes in Stock series. Both available from INEGI with two base years: 1980 constant prices (1980Q1-1995Q4) and 2013 constant prices (1993Q1-2017Q4). The final series is chained to obtain a series in 2013 constant prices.*
K_t	1987Q1-2017Q4	We take the initial value as $K_0 = I_0/\delta$, where I_0 is taken as the mean of I_t from 1982Q2 to 1986Q4 (I_t remained constant on average and $g_I \approx 0$ during this period following the debt crisis in 1982).
u_t	1985Q1-2017Q4	There are three monthly series available: one from ENEU, 1985M1-2005M9 for ages 12 and over, and two from ENOE, 2000M4-2014M9 for ages 14 and over and for ages 15 and over. The final series is properly chained to construct a series for 2005M1-2017M12, working population aged 15 and over.*
p_t	1987Q1-2017Q4	There are three monthly series available: one from ENEU, 1987M1-2004M4, and two from ENOE, 2000M4-2014M9 and 2005M1-2017M12. The final series is properly chained to construct a series for working population aged 15 and over.*
h_t	1987Q1-2017Q4	INEGI reports a series for weekly average hours worked, 2005Q1-2017Q4. The final series is completed by using two monthly series from EIM** 1987M1-1995M12 and 1994M1-2008M12.
N_t	1980Q1-2017Q4	A chained series is constructed for the working population aged 15 and over, Penn World Table: 1980Q1-1989Q4, OECD: 1990Q1-2001Q1, and INEGI: 2001Q2-2017Q4.
ν_t	1987Q4-2017Q4	FRED reports a series of ν_t for Mexico as of 1998Q1. Therefore, we follow Solow (1957) and use $\nu_t \approx 1 - u_t$ as a proxy for the capacity utilization of capital.
Y_t	1980Q1-2017Q4	We chained two series from INEGI** given in 1993 constant prices, 1980Q1-2007Q4, and in 2013 constant prices, 1993Q1-2017Q4, to get a final series in 2013 constant prices.
Parameters	**Value**	**Details**
α	0.31	This is the value used for Mexico by Bergoeing et al. (2002).
δ	6% (annual)	This is the value used for Mexico by Bergoeing et al. (2002)‡.

Note: *The series was seasonally adjusted using the ARIMA-X12 method. **The series is seasonally adjusted from the original source.
INEGI: *Instituto Nacional de Estadística y Geografía* (Mexico's Office of Statistics).
ENEU: *Encuesta Nacional de Empleo Urbano* (National Survey of Urban Employment, introduced in 1987 by INEGI).
ENOE: *Encuesta Nacional de Ocupación y Empleo* (National Survey of Occupation and Employment that replaced ENEU in 2005).
EIM: Encuesta Industrial Mensual (Monthly Industrial Survey carried out by INEGI).
‡: Bergoeing et. al (2002)argue that 6% yields consistent values for the capital-output ratio of the Mexican economy and is a standard value used in both empirical and theoretical analysis in Mexico.



Dotted lines represent the trend of the series estimated via the SAVN filter. SOURCE: Authors' own estimates.

Figure A1: Factor input series.

B Structural break tests applied to the growth rate of potential GDP series (using the SAVN filter)

Kapetanios test: The auxiliary regression corresponds to the intercept model with level shifts (or DU and DT, respectively). We set the maximum number of lags according to the standard *ad hoc* rule $p_{\max} = \left[12\left(\frac{T}{100}\right)^{1/4}\right]$, where T is sample size and $[x]$ denotes the integer part of x, and then test down from the maximum lag. We set five breaks and a trimming of 0.10. The null hypothesis of unit root is rejected at the 5% level.

Table B1: Kapetanios test

Input	Results	Break dates
Bound: 23 Mmax: 5 Kmax: 1	tstat: -28.46* Des: 'Ho rejected'**	1971Q4, 1978Q4, 1985Q2, 1992Q1, 2003Q4

Note: Bound: # of observations between breaks (equivalent to a trimming of 0.10); Mmax: # of Breaks (Max. 5); Kmax: # of lags allowed (Min. 1); *Kapetanios (2005)' values. **Significant at the 5% level.

Bai-Perron testing procedure: The test is applied with a constant as a regressor. We allow for up to five breaks and set a trimming of 0.10. Serial correlation and different variances of residuals along the subsamples are allowed. The null hypothesis of parameter stability is systematically rejected for this series at the 5% level, for between 1 and 5 breaks.

Table B2: Bai-Perron testing procedure

Breaks	F-statistic	Scaled F-stat.	Weighted F-stat.	Critical Value
1*	13.18	13.18	13.18	9.10
2*	49.92	49.92	57.36	7.92
3*	35.54	35.54	47.28	6.84
4*	40.16	40.16	60.61	6.03
5*	53.45	**53.45**	**90.58**	5.37
UDMax statistic* 53.45			UDMax critical value** 9.52	
WDMax statistic* 90.58			WDMax critical value** 10.39	
Estimated break dates				
1	1981Q2			
2	1981Q4, 1988Q1			
3	1981Q4, 1988Q2, 2000Q2			
4	1981Q4, 1988Q2, 2000Q3, 2011Q1			
5	1974Q1, 1981Q4, 1988Q2, 2000Q3, 2011Q1			

Note: *Significant at the 5% level, Trimming 0.10. **Bai and Perron (2003)'s values.

C Structural break tests applied to the growth rate of potential GDP series (using the PF methodology)

Kapetanios test: The auxiliary regression corresponds to the intercept model with level shifts. We set two breaks and a trimming of 0.10. The null hypothesis of unit root is rejected at the 5% level.

Table C1: Kapetanios test

Input	Results	Break dates
Bound: 12 Mmax: 2 Kmax: 1	tstat: −12.69* Des: 'Ho rejected'**	1994Q1, 2010Q4

Note: Bound: # of observations between breaks (equivalent to a trimming of 0.10); Mmax: # of Breaks (Max. 5); Kmax: # of lags allowed (Min. 1); *Kapetanios (2005)' values. **Significant at the 5% level.

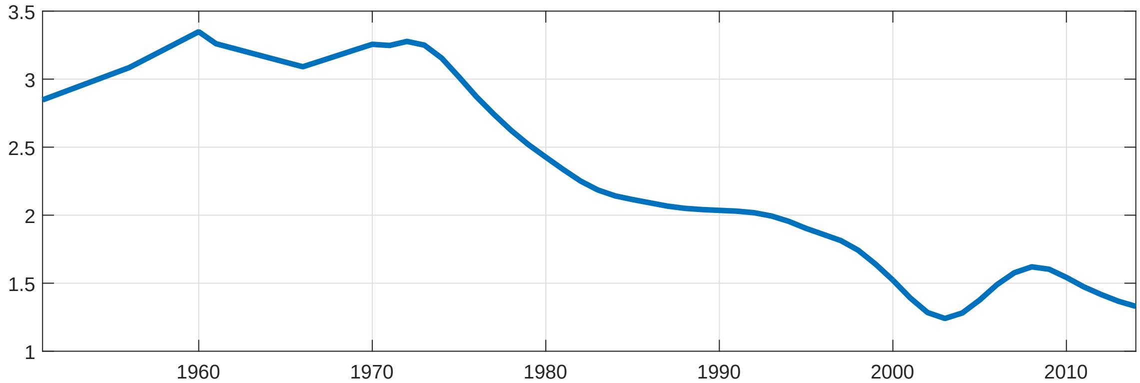
Bai-Perron testing procedure: The test is applied with a constant as a regressor. We allow for up to five breaks and set a trimming of 0.10. Serial correlation and different variances of residuals along the subsamples are allowed. The null hypothesis of parameter stability is systematically rejected for this series at the 5% level, for between 1 and 2 breaks.

Table C2: Bai-Perron testing procedure

Breaks	F-statistic	Scaled F-stat.	Weighted F-stat.	Critical Value
1*	10.95	**10.95**	**10.95**	9.10
2*	8.96	8.96	10.30	7.92
3	6.35	6.35	8.45	6.84
4	5.83	5.83	8.81	6.03
5	4.89	4.89	8.30	5.37
UDMax statistic* 10.95			UDMax critical value** 9.52	
WDMax statistic* 10.95			WDMax critical value** 10.39	
Estimated break dates				
1	2000Q3			
2	2000Q3, 2011Q1			
3	2000Q3, 2008Q1, 2011Q1			
4	2000Q3, 2008Q1, 2011Q1, 2014Q1			
5	1994Q2, 2000Q3, 2008Q1, 2011Q1, 2014Q1			

Note: *Significant at the 5% level, Trimming 0.10. **Bai and Perron (2003)'s values.

D Population growth in Mexico



SOURCE: Authors' own estimates using FRED data.

Figure D1: Mexico, population annual growth rate, 1951-2014.