Mexico: US anchor called into question

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As the only Latin American country in North America, Mexico plays a special role on the continent. Today it is in the frontline of the new US administration's swerve towards protectionism and anti-immigration policies. Despite relatively solid macroeconomic fundamentals, Mexico's economic growth has been disappointing, and its prospects are eroding. The country has to seize the opportunity offered by Donald Trump's challenge to redefine its economic model, lessen its dependence on the United States and strengthen productivity by further integrating in global value chains.

Rising populism and a backlash against globalisation are taking root in the developed countries. Donald Trump's election and Brexit seem to have sounded the death knell for multi-lateral international cooperation and its "institutional and regulatory straitjacket", in favour of bilateralism. Unlike Theresa May and her ongoing support for free trade as the backbone of UK trade policy, US policy is clearly veering towards protectionism under Donald Trump. The rules governing international trade relations are being called into question by their main instigators, creating a major source of uncertainty and concern. Mexico is in the frontline of this policy change, given its dependence on the United States and its economic and financial openness, which lies at the core of its economic model.

Despite generally solid macroeconomic fundamentals, Mexico is exposed to external shocks and a downturn in the sentiment of international investors. Mexico has woven an intricate network of trade agreements with more than 40 countries, foremost of which is the North American Free Trade Agreement (Nafta) signed in 1994. Mexican exports now account for 34% of GDP, up from 14% in 1994. Of these, 75% are manufactured goods (a third for the automobile industry alone), thanks to a highly integrated supply chain with the United States (81% of Mexican exports). Capital controls have been completely eliminated. One of the rare convertible currencies from an emerging country, the Mexican peso (MXN) is also one of the most heavily traded on the financial markets, and international investors are highly active in the local equity and bond markets.

This article will first review Mexico's macroeconomic trajectory since it joined Nafta, and then will examine the new US economic and trade situation and its consequences for Mexico's economy.

An emerging country with the sluggish growth rates of a developed economy

Disappointing economic growth

Mexico entered the new millennium as the leader of Latin America, bolstered by structural reforms (public finance, monetary policy and financial sector reforms) launched after the so-called "Tequila" crisis of 1994-1995, and by its Nafta membership. Yet after five years of exceptional economic growth (5.5% a year on average), several factors marked the end of this buoyant period: the bursting of the dot.com bubble, the New York terrorist attacks, and intense international competition, exacerbated by China's entry into the World Trade Organisation (WTO) in 2001 and the expiration of the Multifibre Arrangement (MFA) in 2005. Since then, Mexico's economic performances have been disappointing. Real GDP growth did not surpass an average of 2.5% in 2003-2015, pulling down Latin America's average economic performance (3.3%) and falling far short of the 6% growth rates reported by the 40 main emerging economies.

Mexico's economy was slammed by the 2008 financial crisis and plunged into recession in 2009 (-4.7%). Exports declined by nearly 12% that year, which had a major gearing effect on domestic demand (-6.2%). As America's workshop and the adjustment variable for the US market, the Mexican economy destroyed 570,000 formal jobs in just a few months, before restoring them again starting in 2010, illustrating the enormous flexibility of the exposed *maquiladora* sector. The slowdown in foreign direct investment (gross FDI inflows averaged USD 26 bn a year in 2006-2015, half of which was from the United States) and transfers from roughly 30 million Mexican descendants living in the United States (USD 24 bn a year on average) also squeezed gross fixed capital formation (GFCF) and household consumption in Mexico in 2009.

Thereafter, Mexico benefited less than the South American countries from the rapid rebound in commodity prices – despite major oil potential – and the dynamic momentum of Asia, especially China. Pemex, the state-owned monopoly since 1938, lacked the financial and technical resources for deep-water exploration and unconventional hydrocarbons. As a result, oil production declined 35% from its 2004 peak, including a 10% decline since the drop-off in oil prices in 2014. With oil production of 2.2 million barrels a day, Mexico now ranks 12th worldwide, down from 5th in 2004.

Yet the country did manage to regain market share in the United States as of 2009 (13.6% in mid-2016 vs. 10.4% in 2008), thanks notably to its renewed cost competitiveness with China (weak peso, lower cost of labour since 2011 and low transport costs). Export growth in volume was a strong 7% in 2014 and 9% in 2015. Mexico generated a trade surplus with the United States of nearly USD 70 bn. It attracted new European and Asian investors despite a tough business climate and the erosion of the rule of law in certain northern industrial regions (violence, battle against/between drug cartels, corruption). Mexico also benefited from technological transfers in aeronautics and other sectors offering higher value-added than automobile assembly and electronics, and it has developed numerous competitiveness clusters.

Real GDP growth and demand components

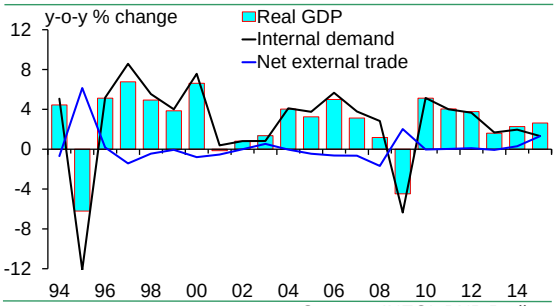


Chart 1 Sources: INEGI, BNP Paribas

Real GDP growth and supply components

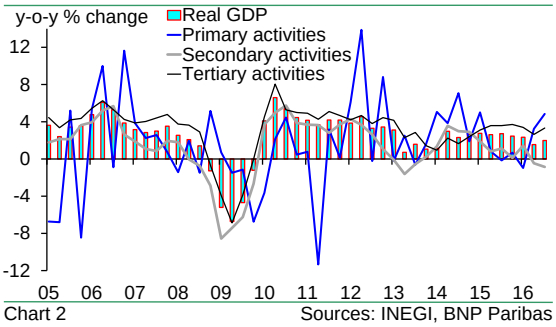


Chart 2 Sources: INEGI, BNP Paribas

Market shares of US imports

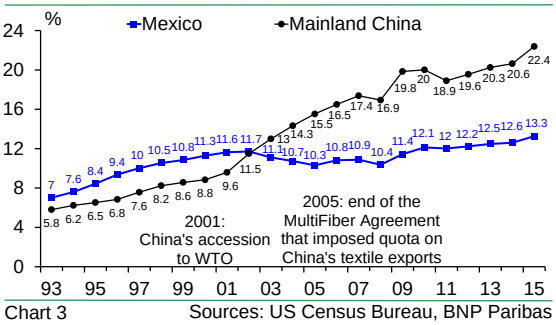


Chart 3 Sources: US Census Bureau, BNP Paribas

The Peña Nieto administration (2012-2018) launched long-awaited structural reforms in energy, competition, telecommunications, taxation, the job market, education and financial services, which were expected to lift Mexico's potential growth rate as of 2015. The government initially planned to boost GDP growth to more than 5%, including one extra point of growth due to the simple opening of the energy market to the international oil giants – but this target seemed very ambitious without an investment effort of at least 6.5% a year and major technical progress resulting from the reforms. It seemed more plausible that average annual growth would rise just above 4% through 2018 (see Conjoncture of May 2014: "Latin America: divergent trajectories").

Unfortunately, economic growth was squeezed in 2016 by financial market volatility in the emerging countries (concerns about China, rising geopolitical risks, and the vicissitudes of monetary policies in the developed countries, notably the Fed), by the US economic slowdown and by Mexico's rather restrictive fiscal policy to counter the decline in oil prices. As a result, full-year GDP growth is estimated at only about 2% on average.

Nafta does not spark catching-up effect or convergence

So far, Nafta has not produced all of the gains expected from the catching-up movement and economic convergence between Mexico on the one hand and the United States and Canada on the other. Ironically, the agreement did not unfold under the most auspicious conditions, since economic and financial deregulation and the capital inflows that began in the late 1980s were one of the vectors behind the Mexican crisis of 1994-1995.

Privileged access to the North American market has had a positive impact on direct and indirect job creations in Mexico. Over the past twenty years, the Mexican economy has created 8 million formal jobs. Export sectors, namely manufacturing industry and part of the agricultural sector, now account for 29% of formal employment. Manufacturing industry alone accounts for 16%, and this figure has been relatively stable for the past decade.

Yet in terms of real GDP, the average annual growth rate has been only 0.3 percentage points higher than in the US since 2001. Over the same period, demographic growth has been extremely dynamic (1.2% vs. 0.9% in the United States). As a result, in purchasing power parity, per capita GDP relative to the US has stagnated at only 32% over the past 20 years (the same level as in the 1950s), even though it had climbed to 46% on the dawn of the 1982 debt crisis.

This trajectory reflects the absence of absolute and relative productivity gains in Mexico. According to Conference Board data, the productivity gap has widened sharply to the detriment of Mexico over the past three decades. Hourly productivity increased 65% in thirty years in the United States, but was stagnant in Mexico. Relative hourly productivity between the two countries dropped from 57% in 1982 to only 31% in 2015 (where it has stabilised since 2011, after dropping sharply in 2008-2010), but the productivity gap per employee is not as big because the average working time in Mexico is 20% longer. In Mexico, total factor productivity (TFP) has declined by 1% a year since 2001 (compared to +0.2% in the United States), illustrating the chasm that still exists between the two neighbours in terms of technical progress (innovation, R&D, quality of human capital).

Reflecting this low productivity, real wages have stagnated, squeezing household purchasing power and restraining private consumption. A conservative banking sector – largely owned by international banks since the 1994-1995 crisis – has not fully played its role of financing the economy, notably for corporate investment. For the private sector, the credit penetration rate is barely 20% of GDP. The government has also had to keep a tight grip on public spending due to the weak tax base and declining oil-related revenues (which fell from a third of total revenues to less than 20% today), which has

hampered public investment in education, healthcare and infrastructure. Lastly, the Mexican economy's duality (export vs. domestic sectors; formal vs. informal employment, which accounts for nearly 60% of total employment) has fuelled big inequalities, although extreme poverty and the official unemployment rate (3.7%) are both low (though the jobless rate only partially reflects the real job market situation).

Growth regime has shown some signs of autonomy

The Mexican and US economic cycles are highly synchronised. Nonetheless, since the financial crisis we can see a weakening of the correlation between GDP growth trends (5-year moving average), although the correlation between Mexican export growth and US import growth remains very high. Through 2008, Mexican growth was more volatile but held relatively close, on average, to US growth. But since then it has grown faster than the United States by nearly a percentage point, even though this growth differential has narrowed over the past two years.

Despite the constraints outlined above, Mexico's growth regime has shown some signs of autonomy in the recent period. The expansion of the tertiary sector (62% of GDP in 2016) via the dynamic momentum of the services sector (+3.7% on average since 2010) has provided a solid source of domestic growth. At the same time, industrial production (i.e. the manufacturing, mining and construction sectors) has only increased 2% and has slowed gradually since 2014, handicapped primarily by the oil sector and to a lesser extent by construction.

Mexico boasts a large domestic market with 120 million inhabitants, of which three quarters belong to the middle class according to an absolute definition (disposable income of between USD10 and USD100 in PPP per day). As a general rule, the consolidation of a country's middle class is a factor that strengthens domestic demand and is synonymous with new means of consumption (services, leisure).

Relative productivity and wealth
Mexico *vs* the US

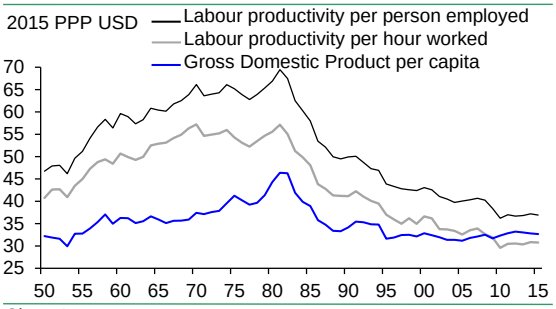


Chart 4 Sources: Conference Board, BNP Paribas

Synchronisation of business cycles

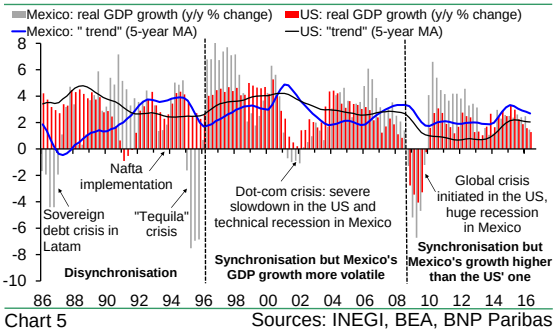


Chart 5 Sources: INEGI, BEA, BNP Paribas

Correlation between Mexico's and the US' economic performance

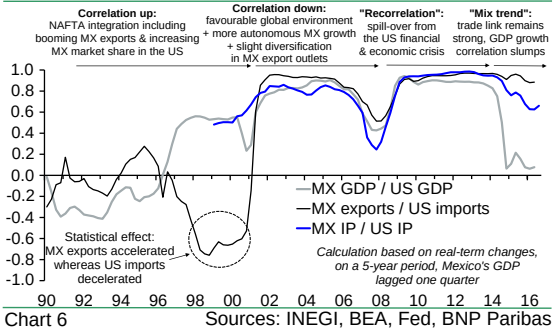


Chart 6 Sources: INEGI, BEA, Fed, BNP Paribas

Of course, the export sector has continued to play a key role as a leverage on the economy as a whole. From a purely accounting perspective, however, the external sector's net contribution to GDP growth is structurally negligible (except in 2015). This can be attributed to the high integration of the production chain within Nafta, which means the dynamic pace of exports in volume is closely correlated with that of imports, notably for intermediate and capital goods. This implies that Mexico is incapable of generating trade surpluses (other than with the United States), especially now that it generates an oil deficit: the country exports crude oil and imports more expensive refined petroleum products and their derivatives.

The authorities' intentions to diversify export markets (Latin America, Europe, and even Asia) have run up against the attractiveness of the United States (a reciprocal force). Mexico is still enclosed in its economic model as the workshop for the world's largest economy, whose potential growth rate has slowed from about 2.5% to 1.8% since the financial crisis according to the Congressional Budget Office (CBO).

It is still hard to evaluate what impact recent and pending structural reforms will have on Mexico's economic growth. According to preliminary estimates, starting in 2015, job market and financial sector reforms could jointly boost Mexico's growth potential by about 0.5 percentage points from a 5-year horizon. On top of this, we can also add the expected impact of the current opening of the energy sector to international investors. The fourth bid to tender was held in early December 2016 – the first to include very promising deep-water hydrocarbon fields – and six others could follow in the years ahead. But the first barrel is not expected until 2020 or so.

Most importantly, president Trump's rhetoric and his first protectionist and anti-immigration measures are a big source of uncertainty and concern for Mexico.

The "US new deal"

The weight of words and the first symbolic acts

Between the announcement effects and enormous uncertainty, the election of the new US president had a positive shock on US confidence (rather unexpectedly) and a predictable negative impact on Mexico. The US equity markets are expecting an acceleration in economic growth and inflation, which combined with corporate tax cuts, should offset higher interest rates (tightening of the Fed's monetary policy, expectations of higher fiscal deficits). According to the University of Michigan's monthly survey, household confidence hit a 13-year high in January. Inversely, higher interest rates and the dollar's appreciation placed a big strain on Mexico. The Mexican peso (MXN) began to depreciate in early May 2016 as Donald Trump's main rivals dropped out of the running to be the Republican candidate. The peso has depreciated by 12% since the 8 November election. CDS premiums on foreign-currency government bonds rose 50 basis points (bp) in just a few days before gradually easing to 155bp on 3 February. The Mexican Stock Exchange's general index has also picked up, but it was still down 3% in the local currency and 13% in USD for the past three months. Yields on 5-year domestic bonds rose 130bp over the period to 7.15%.

Foreign exchange rates

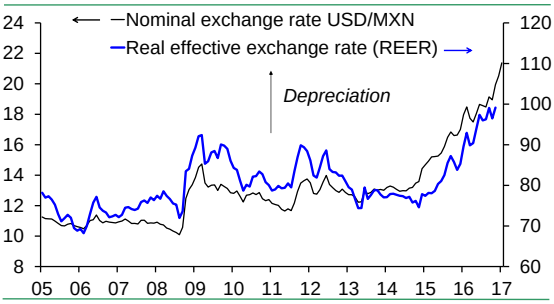


Chart 7 Source: Banxico

The slew of executive orders since the 20 January inauguration shows that Donald Trump intends to rapidly fulfil his campaign promises. The first symbol is the order to withdraw from the Trans-Pacific Partnership, a trade agreement supported by the Republican Party but that had not yet been ratified.

While waiting to renegotiate or even to repeal Nafta, president Trump is threatening to introduce trade tariffs on Mexican imports (a 20% tariff has been mentioned), to encourage US companies to maintain or relocate their businesses to the domestic market. Seventy-five percent of the 500 largest American companies and thousands of SMEs have already located in Mexico. The automobile sector is emblematic: nearly 20% of GM's North American production and 13% of Ford's is located in Mexico. In early January, Ford announced that it would abandon a USD 1.6 bn investment project in a new Mexican plant, and that USD 700 m would be reallocated to its Michigan plant, with the creation of 700 jobs. The Fiat Chrysler group announced that it might withdraw from Mexico depending on the level of import tariffs. At the same time, GM will relocate the production of one of its models in Canada to one of its Mexican sites.

Executive orders on immigration restrictions (the constitutionality of which is still being challenged) and building a wall on the Mexican border (the legal framework has been in place for 10 years but the cost is prohibitive) clearly mark the new administration's determination to restrain the free circulation of both people and goods. The administration is also considering regulatory and fiscal measures restricting money transfers to Mexico (*remesas*) and tighter controls on the status of the people originating these transfers.

Trump doctrine vs. economic reality

The new government's vision is bolstered by Q4 2016 statistics for US economic growth and the trade deficit: according to preliminary estimates, net external trade made a negative contribution to GDP growth of 1.7 points. Despite vigorous consumption and investment in the year-end period, full-year GDP growth slowed sharply in 2016 to an average annual rate of 1.6%, the second weakest performance since the recession ended.

Donald Trump managed to capture the vote of blue collar workers from the Rust Belt against a backdrop of deindustrialisation, impoverishment and downward social mobility. Presenting himself as the advocate of "made in USA", he promised to create 25 million jobs in four years. Although the job market has been particularly buoyant over the past four years, it has "only" created 10 million jobs, slashing the unemployment rate from 8.1% to 4.7%. Unemployment in the broad sense of the term (including underemployment) is two points higher than the 2000 peak of 7%, wage growth has remained subdued and inflation is still in line with the Fed's target (even though it spiked in January, driven by energy prices), which indicates that the economy has not yet reached full employment nor a cyclical peak. Yet even if the labour force were to grow by about 2 million persons a year and economic patriotism were to reach a fervent pitch, Donald Trump's goal of creating jobs seems utopic without resorting to massive immigration. His infrastructure stimulus plan might boost job creations in construction, a big employer of immigrant workers, notably Mexicans. The same can be said about the agriculture and agri-food sector, which along with the industrial sector, is likely to be at the heart of Nafta renegotiation.

Nearly 5 million American jobs depend on trade with Canada and Mexico. For every dollar exported by the Mexican *maquiladoras,* inputs (intermediate goods) from the United States account for no less than 40 cents. Moreover, higher import tariffs would increase import prices, which in the absence of competitive substitutes "made in USA", would end up eroding the purchasing power of US consumers.

Institutional and legal checks and balances

Confronted with economic reality and major institutional safeguards (the separation of powers and the major prerogatives of Congress, the courts and the States), the new US administration will need the support of the Republican majority in Congress to

implement its programme. The Republicans widely support the proposal for massive corporate tax cuts. Yet Paul Ryan, the influential chairman of the House of Representatives, continues to advocate free trade and oppose government intervention. His doctrine does not sit well with Donald Trump's plans for greater protectionism and a stimulus package based on federal infrastructure investment (which may take the form of investment tax credit for companies). Some Republican congressmen might see renegotiating Nafta as an opportunity to strengthen America's economic interests. Nonetheless, it is bound to encounter some powerful opposition. The biggest pressure will come from lobbying by major companies and business sectors that have a big interest in maintaining the status quo, and of course, from the "fourth estate", i.e. the press and the media.

Under article 2205, a Nafta country has the right to unilaterally withdraw from the agreement by simply providing written notice 6 months in advance. It remains to be seen whether the US president has the legal capacity to make such a decision via a simple executive order: article 1-8 of the US Constitution stipulates that questions pertaining to international trade are the prerogative of Congress. Mexico could also file suit with the World Trade Organisation (WTO), if the US administration decided to impose tariff barriers or discriminatory regulations, which are prohibited under the most favoured nation clause in trade agreements.

Mexico's economic prospects

Against this backdrop, we now look at the concrete consequences that future US economic and trade policies could have on Mexico's economic performance. We used a vector auto-regression (VAR) econometric model to evaluate the effects of different external economic and financial shocks on economic activity in Mexico.

Our model can be written as follows[1]:

$$y_t = [\Delta y_t^{US},\ IR10_t^{US}, Spread_t\ , RER_t\ , \Delta y_t^{Mex}, IR_t^{Mex}]$$

where Δy_t^{US} is real US GDP growth, $IR10_t^{US}$ is the interest rate on 10-year US Treasury bonds, $Spread_t$ is the yield spread on 10-year Mexican government bonds in foreign currency, RER_t is the real exchange rate of the peso against the US dollar, Δy_t^{Mex} is real Mexican GDP growth and IR_t^{Mex} is the Mexican interbank interest rate. The breakdown of annual Mexican GDP growth (Cholesky matrix) confirms that external factors are key explanations, mainly US GDP growth (31%) and yield spreads (20%), which are influenced by international market conditions, but also by internal factors specific to Mexico (political risk, stability of public finances).

The results of our simulation, summarised in Table 1, can be interpreted as follows: an initial shock on US GDP growth of 1 percentage point (pp) would generate an instantaneous response of 0.24 pp of real GDP growth for Mexico, a cumulative response over four quarters of 0.86 pp, and a cumulative response over eight quarters of 0.98 pp.

Impulse response of real Mexican GDP to external shocks (standardised at 1 percentage point)

	Real US GDP	US 10-year rates	Yield spreads	Real exchange rate MXN/USD
Q1	0.24	-0.11	-0.16	-0.13
Cumul Q1-Q4	0.86	-0.55	-0.81	0.09
Cumul Q5-Q8	0.12	-0.09	0.29	0.20
Cumul Q1-Q8	0.98	-0.63	-0.52	0.29

Table 1 Source: BNP Paribas

Using VAR, we construct a system of equations to predict real GDP growth for Mexico using the following three alternative scenarios based on whether or not Donald Trump's programme is realised (see table 2):

1. S1: the most favourable scenario for Mexico

US GDP growth accelerates to an annual average of 2.3% in 2017 and 2.8% in 2018, bolstered by a fiscal stimulus package (infrastructure), corporate tax cuts (acceleration of investment and job creations rather than hoarding or dividend payments) and financial deregulation (acceleration of lending). At the same time, we consider a mild increase in tariffs on Mexican imports, which would be proxied by a 10% appreciation in the real exchange rate in Q3 2017.

2. S2: intermediate scenario

The same assumptions for US growth as in S1, but with the introduction of major tariff and non-tariff barriers on Mexican goods, which would be proxied by a 30% appreciation in the real exchange rate in Q3 2017.

3. S3: worst-case scenario for Mexico

No stimulus in the US (GDP growth would average between 2% and 2.2% in 2017-18) accompanied by major trade barriers, identical to those in S2.

We conclude (see chart 8) that under the most favourable scenario (S1), Mexican economic growth would stall on a year-on-year basis in Q4 2017 and Q1 2018, reducing the carryover for 2018, before regaining some traction to finish 2018 with an average annual growth rate of 0.5%. In both S1 and S2, real GDP growth would average 1.2% in 2017. Yet in S2, economic activity would slump from Q1 2018-Q3 2018 (on a year-on-year basis). This would bring average GDP growth to -0.3% in 2018. Lastly, under worst-case scenario S3, real GDP would remain in negative territory until early 2019. It would increase at an average annual rate of 1.1% in 2017 before contracting 0.5% in 2018.

Hypotheses for explanatory variables

	Y_US	IR_US10	Spread	RER	IR_MEX
			Scenario 1		
2017 Q1	2.2	2.6	232	729	6.8
2017 Q2	2.4	2.8	232	729	7.8
2017 Q3	2.2	2.9	232	656	8.0
2017 Q4	2.4	3.0	232	656	8.0
2018 Q1	2.6	3.2	232	656	8.0
2018 Q2	2.8	3.3	232	656	8.0
2018 Q3	2.8	3.4	232	656	8.0
2018 Q4	2.9	3.5	232	656	8.0
			Scenario 2		
2017 Q1	2.2	2.6	232	729	6.8
2017 Q2	2.4	2.8	232	729	7.8
2017 Q3	2.2	2.9	280	510	8.0
2017 Q4	2.4	3.0	280	510	7.8
2018 Q1	2.6	3.2	280	510	7.5
2018 Q2	2.8	3.3	280	510	7.5
2018 Q3	2.8	3.4	280	510	7.5
2018 Q4	2.9	3.5	280	510	7.5
			Scenario 3		
2017 Q1	2.2	2.6	232	729	6.8
2017 Q2	2.0	2.8	232	729	7.8
2017 Q3	1.9	2.9	280	510	8.0
2017 Q4	2.1	3.0	280	510	7.8
2018 Q1	2.2	3.0	280	510	7.5
2018 Q2	2.3	3.0	280	510	7.5
2018 Q3	2.3	3.0	280	510	7.5
2018 Q4	2.1	3.0	280	510	7.5

Table 2 Source : BNP Paribas

Mexico's GDP growth projections

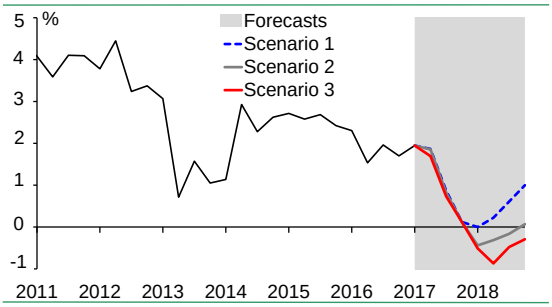
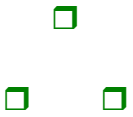


Chart 8 Source: BNP Paribas



Renouncing the principles of openness that have forged the identity and wealth of the United States is probably not a panacea for the economic and social ills plaguing the country. Mexico seems to be the sacrificial lamb and collateral victim of the economic and trade policies being pushed by the new US administration. Under these conditions, Mexico's short-term economic prospects have been revised significantly downwards. The consensus forecast of economists for 2017 GDP growth was lowered from 2.2% in October 2016 to 1.5% in January's latest survey, while 2018 prospects were lowered from 2.8% to 2.1%, respectively.

Whatever the US decides, and even though it will probably take several months or even quarters before any policy changes actually materialise, the size of the negative shock on confidence and the wait-and-see behaviour of non-resident and local investors are likely to have a big impact on investment spending in Mexico in the months ahead. Consequently, investment is likely to contract in 2017. Already shaken by a big fuel price increase announced in January, household confidence is also expected to deteriorate, straining private consumption. Nor should we expect any support from economic policies. Fiscal policy is likely to remain relatively restrictive, as it has been over the past two years, against a backdrop of declining oil revenues and the financial difficulties of the state-owned company Pemex. Constrained by the peso's sharp drop and surging inflation, the monetary authorities are likely to tighten monetary conditions more severely than was expected just a few months ago, largely leading the Fed rather than following behind. Paradoxically, exports might end up being the only support factor for economic growth while awaiting the concretisation of US trade retaliation measures.

In the longer term, the potential scope of the economic, trade and diplomatic policy shifts that could be introduced over the next four years is alarming when it comes to Mexico's trajectory. Undermined by its comparative and competitive advantages that have trapped itself into the role of a workshop for its Northern neighbour, Mexico must redefine its economy model, lessen its dependence on the United States and strengthen its productivity by further integrating in global value chains. Seen in this light, the acceleration of trade negotiations between Mexico and the European Union should be considered to be good news.

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NOTE

[1] Considering that the 1994-1995 crisis and the start-up of Nafta marked a structural rupture for the Mexican economy, we have calibrated our model on the period Q1 2000 - Q4 2016 (quarterly data) to evacuate the memory effect (persistence of past phenomenon).

We consider $VAR(p)$ with n variables:

$$Y_t = \Phi_0 + \Phi_1 Y_{t-1} + \Phi_2 Y_{t-2} + \ldots + \Phi_p Y_{t-p} + \varepsilon_t \qquad (1)$$

where p^* is the optimal number of lags and ε_t is white noise

The equation (1) can be rewritten: $\Phi(L)Y_t = \Phi_0 + \varepsilon_t$ (2)

With L the lag operator, I_d the identification matrix, $\Phi(L) = I_d - \sum_{i=1}^{p} \Phi_i L^i$

Under the stationarity hypothesis, the Wold theorem allows us to rewrite the VAR process as an infinite order moving average ($VMA(\infty)$):

$$Y_t = \sum_{j=0}^{\infty} \psi_j \varepsilon_{t-j} = \Psi(L)\varepsilon_t \qquad (3)$$

where $\Psi(L) = \sum_{j=0}^{\infty} \psi_j L^j$, $\psi_0 = I_d$ and ε_t represents the shock vector of the process.

Using equation (3) we can determine the shock effect ε_t on endogenous variables.

Therefore:

$$\psi_{h(i,j)} = \frac{\partial Y_{i,t+h}}{\partial \varepsilon_{j,h}}$$

($\psi_{h(i,j)}$ is the partial derivative of $Y_{i,t+h}$ with relation to $\varepsilon_{j,h}$)

$\psi_{h(i,j)}$ is the estimated impact of shock ε_j at date t on variable Y_i for h periods following the shock.

∗ The choice of the number p of lags that minimises the Akaike information criterion (AIC) and Schwarz criterion (SC) are defined as follows:

$$AIC(p) = \log\left[det\widehat{M}\right] + \frac{2}{N}pk^2 \qquad SC(p) = \log\left[det\widehat{M}\right] + \frac{\log(N)}{N}pk^2$$

where k is the number of variables in the system, N the number of observations and $\widehat{M}$ an estimator of the variance-covariance matrix of the residuals.

For our study, we have selected 3 lags.

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