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The effect of natural gas shortages on the Mexican economy☆

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ABSTRACT

The Mexican economy experienced a shortage of natural gas from the second quarter of 2012 through the second half of 2013. In order to deal with this problem, the state-owned national supplier of natural gas (Pemex) implemented a system that restricts the amount of natural gas used by the manufacturing sector. With this information, we have constructed a "shortage index" that represents the percentage of natural gas restricted per month in each region. We quantify the effect of natural gas shortages on the manufacturing sector and GDP using a panel data model with state and time fixed effects. We estimate that the natural gas shortage reduced Mexican GDP annual growth rate by 0.28 percentage points in the second quarter of 2013.

1. Introduction

Natural gas is an important input in many manufacturing industries, therefore shortages can disrupt production and reduce production levels. If such shortages are widespread, the problem can affect aggregate production levels. Unexpected shortages also affect the capability of the firms to react to the problem and exacerbate the adverse effects. Gas shortages disrupt different manufacturing sectors in distinct ways: those that are more intensive in the use of natural gas, such as fabricated metals and machinery experience greater disruption (for detailed energy intensive sectors see the U.S. Conference of Mayors, 2013). The Confederation of Industrial Chambers of the United States of Mexico (Concamin in Spanish) estimates that manufacturing firms lose an average of 150 million dollars with each critical alert (gas outage event), see Concamin. In this paper we estimate the effect of natural gas shortages on the manufacturing sector and on the economy.

To our knowledge, this is the first study that evaluates the economic impact of a particular episode of natural gas shortage. However, there is related literature that studies gas shortages. Barril et al. (2015) explore the reasons behind the natural gas outages in the Argentinian economy in the first decade of the 2000's. They estimate a production function from a panel of regions and conclude that the government's price policy discouraged investment and production of natural gas in Argentina. Similarly, MacAvoy (1971) and MacAvoy and Pindyck (1973) study natural gas shortages in the United States in the late 1960's. They focus their analysis on exploration and production of natural gas and conclude that these shortages were the consequence of a poor pricing policy implemented by the Federal Power Commission's Bureau of Natural Gas. Leahy et al. (2012) estimated the hypothetical impact of natural gas shortages on the Irish economy. The authors use a static accounting approach to estimate the potential effect of these shortages on production. From the national account input–output matrix they obtain the amount of natural gas as a proportion of the total inputs of each sector, and multiply it by the sector's participation in GDP. The main disadvantage of this approach is that supply chain linkages between industrial sectors mean that a halt to production in one sector can have an adverse effect on production in another, which can lead to underestimation of the shortage effect. Another potential problem is that the

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continuation of productive, though limited activity, during outage and the possibility of subsequently recovered production can lead to overestimations (see Frayer et al. (2013)).

Given that the data available does not allow to estimate the effects of shortages directly on GDP, in this study we estimate the effect of natural gas shortages on the manufacturing sector using a fixed effects model that includes a measure of the shortage as an independent variable, as well as other determinants of production. We obtain the total effect of gas shortages on Mexican GDP by estimating second-round effects of the manufacturing sector on other economic sectors. This allows us to control for particular state features (both observable and unobservable) which do not change over time and could affect the dependent variable and the variables of interest. The panel characteristics of the data also allow us to capture the possibility of subsequently recovered production to compensate for output lost during the outage. The results suggest that in the absence of a natural gas shortage, the quarterly seasonally adjusted growth rate of GDP in the second quarter of 2013 could have been −0.27%, rather than the observed −0.55%. Thus, the shortage problem can explain an important part of the decline in GDP during this quarter.

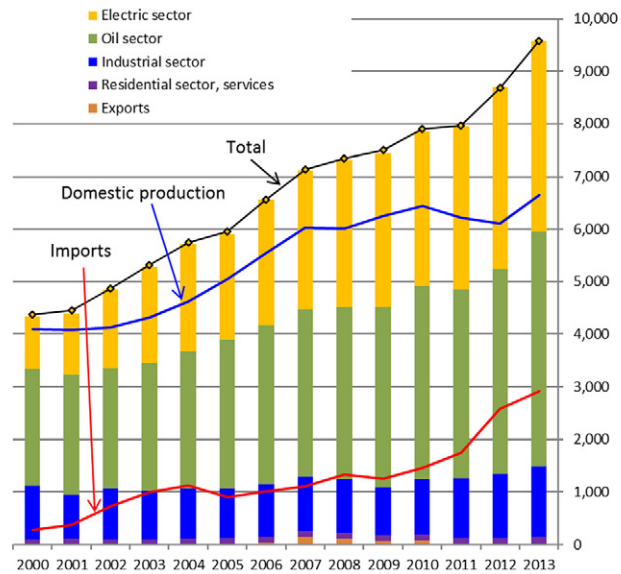

Fig. 1. Natural gas demand, production and imports in millions of cubit feet per day. Source: Ministry of Energy, Mexico.

2. Natural gas in Mexico

Shale gas has experienced a remarkable boom in the United States in the last decade. In 2000, it represented only 1.6% of total natural gas production in that country. Production jumped to 4.1% by 2005 and to 23.1% by 2010. This *energy revolution* reduced the price of natural gas in the U.S.: the price fell from 7.7 to 3.8 dollars per thousand cubic feet from 2007 to 2012. A natural gas pipeline infrastructure connecting Mexico to the U.S. network allows it to import natural gas from its northern neighbor at a relatively low cost. Thus the Mexican prices' trajectory mirrored that of the U.S. Since the price reduction seemed permanent,[1] many firms in Mexico switched to natural gas as a source of energy, and demand increased sharply (see Fig. 1).[2]

Despite geological similarities between Mexico and the U.S. the Mexican state oil monopoly, Pemex, did not take advantage of shale gas exploitation. Energy regulations prior to Mexico's recent energy reform did not allow companies other than Pemex to exploit hydrocarbons or their derivatives.[3] Shale gas production requires small-scale production companies (see Wang and Krupnick (2013) and Critchlow and Apte (2012)). Given Pemex's large scale-production, it is not surprising it continues focused on oil, extracting gas mainly as a by-product. Another problem is that the government price-setting mechanism seems to underestimate the real market price of gas by not fully accounting for transportation costs and investment required to increase pipeline infrastructure to import natural gas from the U.S.[4] This underestimation had two effects on the energy market in Mexico. First, it provided further stimulus to demand growth and, second, with the prevailing low price it was even less profitable for Pemex to invest in natural gas transportation or production infrastructure.[5] As a result, the increasing use of pipelines to import natural gas from the U.S. was not matched with more investment in infrastructure. Consequently, the system entered a vulnerable zone in the second half of 2012. Since the events happened in a short period of time, the industry did not have time to react and change production plans and the manufacturing sector experienced random shortages from April 2012 until July 2013.

In order to deal with the shortage problems in the short run, Pemex implemented a system of *critical alerts* which consisted of asking firms from particular states to limit their natural gas consumption for a period of time by a fraction of their historical consumption. This measure reduced the availability of natural gas and affected the productive capacity of the manufacturing industry, and thus, the level of economic activity as a whole.

3. Data and descriptive analysis

Our main independent variable is an indicator of the degree of natural gas shortage that was elaborated with data from Pemex and Concamin's Energy Commission. This indicator varies over time and by state according to the following formula:

$$D_{it} = percentage_{it} \times \left(\frac{numberofdays_{it}}{30}\right) \tag{1}$$

[1] The futures of U.S. natural gas suggest this. Additionally, according to the U.S. Energy Information Administration (2010), the probability of the price falling below the present price is > 50 %.

[2] The ability to switch among fuels varies widely across the manufacturing sector. The production process of nitrogenous fertilizer is able to substitute for $< 1\%$ of its natural gas use. On the other hand, the production of plastics and rubber products can switch nearly 40% of their fuel source (see U.S. Energy Information Administration (2013)).

[3] Mexican petroleum law: *Ley Reglamentaria del Artículo 27 Constitucional en el ramo del Petróleo*. The secondary laws of the energy reform that allow private investment in this sector were promulgated in August 2014.

[4] In Secretaría de Energía (2012) the Ministry of Energy sets the new guidelines for setting natural gas prices and recognizes that the previous mechanism systematically underestimated the prices.

[5] In National Commission of Hydrocarbons (2012) the CNH evaluates possible investments according to the hydrocarbon reserves of January 2012 and ranks projects according to their profitability. The evaluation of natural gas investments uses a price of 4.5 dollars per thousand cubic feet of natural gas. This price is relatively close to the U.S. export price observed during the last months of 2011, but it seems low compared to the historical path levels, and is below the mean both U.S. export and U.S. industrial prices (see Fig. 2). This argument takes on greater cogency when we consider that private investment in natural gas transportation infrastructure has been allowed in Mexico since the energy reform of 1995, yet private investment in this sector has been virtually zero since then. It seems that the problem persists: *Los Ramones* investment tender project, one of the most important in the natural gas industry, was declared deserted by Pemex in 2013 after private investors showed little interest. Pemex announced that it will continue with the project with public resources. In 2015, Pemex announced that BlackRock and First Reserve funds will participate with only the 45 % of the total investment required to complete the project.

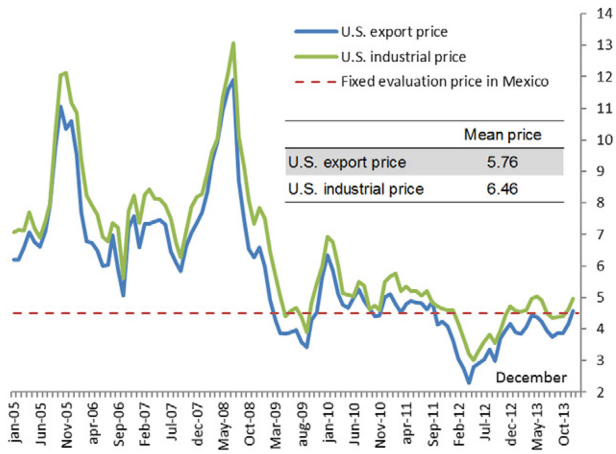

Fig. 2. Natural gas prices in dollars per thousand cubic feet.
Source: EAI and CNH.

where *percentage*$_{it}$ is the percentage of reduction in month t with respect to historical consumption of natural gas in state i and *number of days* is the number of days that the reduction is in force. For example, if natural gas use was rationed to 10% less than the historical consumption over 5 days in a month of 30 days, the indicator takes the value of 0.016 (10% multiplied by 5 days divided by 30 days).[6] Therefore, this index goes from 0 that indicates no shortage in a particular month, to 1 that means total halt in gas supply during one month.[7] Since we want to estimate the effect of natural gas shortages on the economy, the dependent variable used is the state-level manufacturing index obtained from the Mexican National Institute of Statistics and Geography (INEGI) . Monthly state GDP data is not available in Mexico, therefore is not possible to estimate directly the effect of gas shortages on GDP.[8]

Natural gas shortages did not affect regions in Mexico evenly. Fig. 3 shows the average level of shortage per region. The most affected regions were the center and mid-west. In contrast, the northwestern region suffered no shortage. According to the Ministry of Energy, the center and mid-west were affected by bottlenecks in the pipeline infrastructure for importation and distribution from the U.S. (see Secretaría de Energía (2012)). The northern region, which is closer to the source of the imported natural gas, experienced no serious problems. Shortages were not evenly distributed over time either. Fig. 4 shows the distribution of the average shortage index over in time. It is noteworthy that there was a spike in September and October of 2012, whereas the greatest rationing was registered in the second quarter of 2013. After the third quarter of that year no new critical alerts were issued. We exploit this geographical and temporal variation in outages to identify the effects of natural gas shortages on the economy.

Descriptive evidence suggests that the natural gas shortage seems to have affected manufacturing production. Fig. 5 shows the relation between the natural gas shortage and manufacturing production for the three groups of states: high shortage, medium shortage, and no shortage. The states with high and medium shortages registered a more pronounced slowdown beginning in the second half of 2012, and they did not recover in 2013. In contrast, states with no shortages showed a positive trend during 2013. It should be noted that the high shortage group has the highest share of total manufacturing production.

4. Econometric analysis

We used monthly state-level panel data from January 2010 to August 2013 to estimate a fixed effects model with the logarithm of the monthly manufacturing production index as the dependent variable and the shortage index as the main independent variable:

$$\ln(y_{it}) = \phi D_{it} + \beta \ln(ipius_t) \times \pi_i + \gamma \pi_i + \delta T_s + u_{it}$$

where

y_{it}	is the seasonally adjusted manufacturing production index of state i in month t;
D_{it}	is the measure of natural gas shortage;
$ipius_t$	is the seasonally adjusted industrial production index in the U.S.;
π_i	are the state fixed effects;
T_s	are the monthly seasonal fixed effects; and
u_{it}	is the error term.

The inclusion of fixed state effects allows us to control for particular state features (both observable and unobservable) which do not change over time and which could affect the variables of interest and the independent variable. For example, states characterized by inferior infrastructure could generally be more prone to shortages and lower industrial production. Given that the level of infrastructure hardly changes during the time span of this study, heterogeneity in infrastructure among states is captured in the state fixed effects and will not bias the results.

In addition, we control for the important seasonal differences in demand for natural gas with monthly seasonal dummy variables, as has been done in other studies (Egging and Gabriel (2006) and Rogel-Salazar and Sapsford (2014) among others). Taking into account the influence of the U.S. industrial activity on the Mexican manufacturing production, we control for the U.S. industrial production index (Ipius). We interact this variable with a state dummy variable in order to account for the stronger link between the U.S. and northern states than the rest of the country. In Table 1 we show descriptive statistics of the variable used in the econometric analysis.

The natural gas price is not included in the regression because, as explained in Section 2, prices are not determined by the market but by the government, and showed little variation during the time span of the analysis. Another reason to not include prices is that this variable is endogenous given that changes in prices could affect both, demand and supply, with opposite effects on quantity.

In order to verify the robustness of the results and choose the preferred estimation, we test the convenience of including different explanatory variables. In Table 2 we present the results for four specifications: (1) includes the logarithm of the Ipius interacted with a dummy variable by state and state fixed effects; (2) adds a trend variable; and (3) replaces the trend variable with monthly seasonal effect. Finally, to check for the possibility of nonlinear effects, in (3.1) we add a quadratic shortage term.

[6] Instead of dividing the number of days with shortage by 30, an alternative would be to use the number of business days per month, it is important to underline that the number of days chosen to construct the index has no effect on the results presented in this paper.

[7] There are two reasons why the shortage index may vary: i) by changes in the period of time of the shortage or, ii) by changes in the percentage of the shortage. In the preferred specification, the relationship between these variables is linear (see Eq. (1)). In other words, having one day with 100% of shortage is equivalent to having two days with 50% of shortage in each day.

[8] The only GDP data available at state level is yearly data. Given that the shortages last only for a few days and have an immediate effect on manufacturing production, yearly information is not suitable to estimate the effects we want to identify. Other reason to estimate the effects on the manufacturing sector is that the whole economy could be simultaneously affected by many other factors besides the shortages, making it more difficult to identify the effects we are interested in. In contrast, the manufacturing sector was directly affected by the shortages, making it feasible to identify the causal effects of the gas shortages.

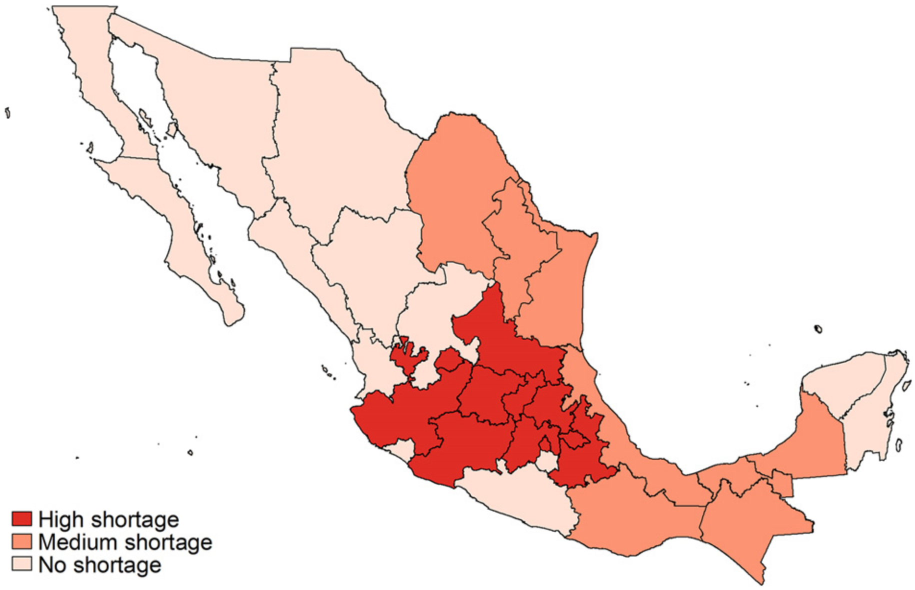

Fig. 3. Mexican states by level of natural gas shortage.
Source: Authors' elaboration with data from Concamin. We obtained the level of natural gas shortage by region using data from Concamin. The center and the mid-west are high shortage regions, south and northeast regions are medium shortage regions, and the north as well as states without access to natural gas are regions with no shortage. The high shortage region includes states that have an average shortage index above the mean of the distribution for states that experimented gas shortages.

To evaluate the different specifications, we performed a linear hypothesis test (Wald test) on the parameters of the added control variables to verify whether their coefficients are jointly statistically different from zero. In specification (2) the trend variable is not statistically different from zero. In specification (3), we cannot reject the hypothesis that all the monthly seasonal coefficients are different from zero at a 5 percent confidence level. Finally, when we add the linear and quadratic terms to regression (3.1) both coefficients of interest became non statistically different from zero, suggesting that the quadratic term does not improve the model's specification, making (3) our preferred specification.

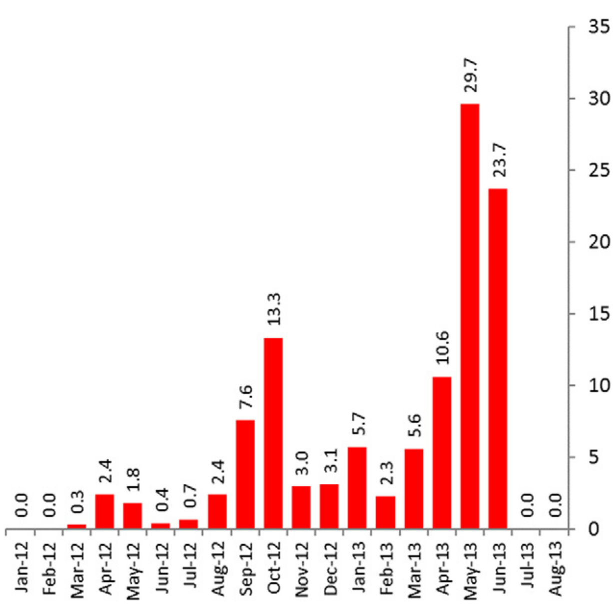

Fig. 4. Average state shortage index in percent.
Source: Authors' elaboration with data from Concamin.

4.1. Regression results

As expected, the coefficient of the shortage index is negative in all the proposed specifications. Since natural gas is an input for the production process in the manufacturing industry, an exogenous shortage of gas induces a lower output. According to our preferred

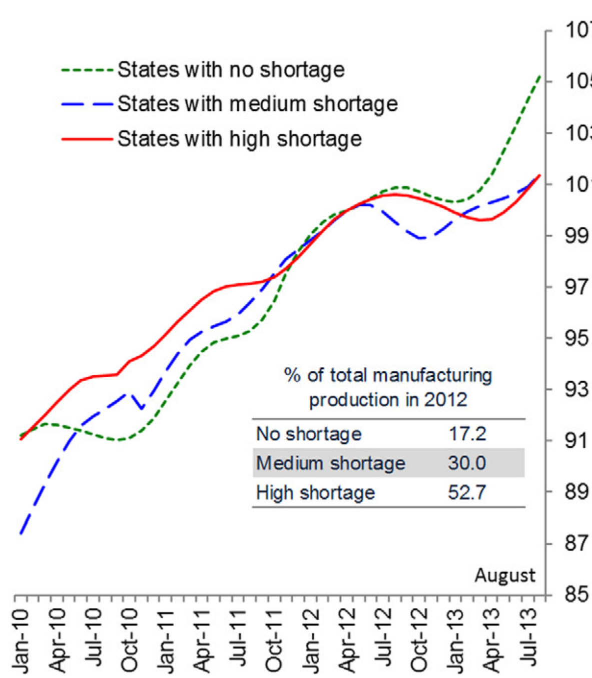

Fig. 5. Manufacturing production, Index Apr-2012 = 100. Trend series.
Source: Authors' elaboration with data from Concamin and INEGI. Note: We used state manufacturing GDP of 2011 to calculate the level of manufacturing production by state. In order to obtain the production level over time, we used the monthly change from the manufacturing production index by state published by INEGI. The index is the sum of states' production that belong to each group. The level of natural gas shortage was determined by region using data from Concamin: center and mid-west are high shortage regions, south and northeast are medium shortage, and northern states as well as states without access to natural gas correspond to the regions with no shortage.

Table 1
State-level data summary statistics.

Variable	# Obs	Mean	s.d.	Min	Max
ln(Manuf. Prod.)	1408	4.65	0.11	4.26	4.96
Ipius	1408	94.7	3.27	87.96	99.54
Shortage > 0	222	0.16	0.19	0.003	0.73
Shortage by region					
No shortage	572	0	–	–	–
Medium > 0	57	0.12	0.14	0.003	0.73
High > 0	165	0.18	0.20	0.01	0.73

Table 2
Estimation of the effect of natural gas shortages on manufacturing production. Cluster robust standard errors by state in parentheses.

ln(Manufacturing Production$_{it}$)	(1)	(2)	(3)	(3.1)
Shortage$_{it}$	−0.025**	−0.027**	−0.032**	−0.045
	(0.012)	(0.012)	(0.013)	(0.070)
Shortage squared$_{it}$				0.021
				0.101
Trend$_t$		0.0002		
		(0.0009)		
ln(ipius$_t$)π_i	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes
Monthly seasonal effects	No	No	Yes	Yes
Cluster standard errors by state	Yes	Yes	Yes	Yes
Number of observations	1408	1408	1408	1408
R-squared	0.826	0.826	0.827	0.827

*** Significance level: 1%.
** Significance level: 5%.
* Significance level: 10%.

specification (3), an increase of 10% of shortage reduces the manufacturing production by 0.32%.

4.2. Exogeneity of the shortage index

Gas shortages are by nature unexpected providing support to the exogeneity of our main dependent variable. However, reverse causality could be a concern if an important rise in the industrial demand in a given quarter and in a given region leads to an increase in the likelihood of shortages, or if the planners operating the rationing system took the expected local demand into account when deciding how best to operate the system. We deal with this potential problem in our identification strategy by two means. First, we use circumstantial evidence, the growing demand, as its explained before in this paper, has indeed an important role to explain gas shortages, however, this was a low frequency pattern in which demand expanded steadily over the years. Once the system reached its saturation limit, according to industry reports,[9] small problems like electrics complications in pumping stations could detonate a critical alert. Given this dynamic, critical alerts were mainly reactive to small problems and not preventive. Second, in order to verify the exogeneity of our main variable, we estimate the same model with a Generalized Method of Moments (GMM, see results in Appendix A).[10] This econometric model uses lags of the variables included in the regression in order to instrument for the variable shortage index. The results are virtually

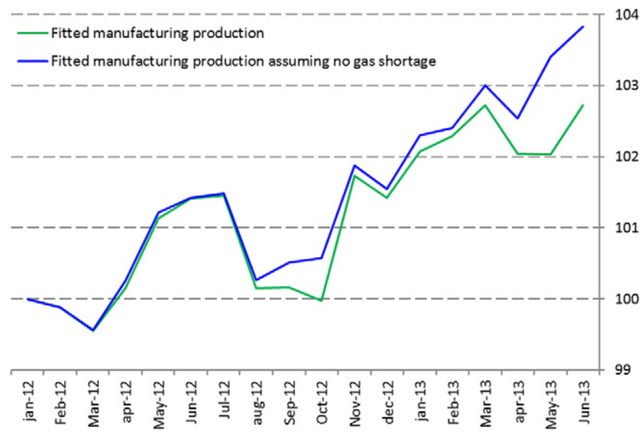

Fig. 6. Sum of state total manufacturing production. Index Jan 2012 = 100. Seasonally adjusted series.
Source: Authors' estimates with data from INEGI.

equal to our main result, which suggest that the bias caused by the possible endogeneity of our main dependent variable is close to zero.

4.3. Quantifying the effects of the natural gas shortages on the Mexican economy

In order to quantify the impact of the gas shortage on the Mexican manufacturing sector, we calculated the *fitted* values of the manufacturing production index per state with the estimated model using the original data.[11] Then, we obtained a *fitted* manufacturing production index assuming that there was no shortage, i.e. the variable D_{it} is zero in all observations. The difference between the two series can be attributed to the effect of the natural gas shortage.

The INEGI publishes the level of manufacturing production by state once a year. Monthly manufacturing production data by state is available only in index format. We thus had to recover the level of monthly manufacturing production by state. We used the level of the state manufacturing production in 2012. Then, with the monthly index growth rate obtained by the fitted series from the model, both with and without shortage, we constructed a monthly manufacturing production level by state. Finally, by adding the production of each state, we obtained the aggregate fitted production with and without gas shortages. Results are presented in Fig. 6. The difference between the fitted production with the observed gas shortage and the fitted production assuming no shortage represents the loss of production as a consequence of the natural gas shortage. These results indicate that the greatest impact of the shortage took place in the second quarter of 2013.

Table 3 shows the annual seasonally adjusted percentage changes in manufacturing GDP, estimated under the scenarios with and without shortages. We calculate the annual growth rate of the manufacturing sector for both scenarios and the difference between them. The most negative effect was observed in the second quarter of 2013. This result suggests that the manufacturing sector growth rate in that quarter was approximately two-thirds of what it would have been in the absence of shortage.

Considering that manufacturing production is linked to other productive sectors,[12] like commerce and transportation, a negative shock on manufacturing indirectly affects the rest of the country's economic activity. Thus, to obtain the total impact on GDP we have to take into account the manufacturing multiplier effect.

[9] This information comes from conversations with Concamin staff and industry reports (see Reforma (2012), El Norte (2012), and El Informador (2012), among others).
[10] We followed the work of Arellano and Bond (1991) and Blundell and Bond (1998), by estimating a GMM difference and system model. An alternative would be an Instrumental Variable regression however, due the difficulty to predict the shortages, we could not find a suitable valid instrument.
[11] Since the dependent variable in our model is in logarithms, to avoid the retransformation bias, we used the *smearing estimate* proposed in Duan (1983).
[12] See World Economics Forum (2012).

Table 3
Impact of natural gas shortages on manufacturing production, annual change.
Source: Authors' estimates with data from INEGI.

	2012-I	2012-II	2012-III	2012-IV	2013-I	2013-II
Manufacturing sector						
Model with shortage (annual s.a. Δ%)	4.37	4.88	3.50	2.79	2.55	1.35
Model excluding shortage (annual s.a. Δ%)	4.37	4.95	3.67	3.08	2.76	2.27
Difference's shortage impact (pp)	0.00	−0.07	−0.17	−0.29	−0.21	−0.92

Table 4
Impact on Mexican GDP growth rate.
Source: Authors' estimates with data from INEGI.

	2012-I	2012-II	2012-III	2012-IV	2013-I	2013-II
Impact on GDP						
Total impact on GDP (pp on annual s.a. Δ%[a])	0.00	−0.03	−0.06	−0.11	−0.07	−0.34
With shortage (observed)	0.67	1.67	0.10	0.78	0.20	−0.55
Excluding shortage (counterfactual)	0.67	1.69	0.13	0.82	0.17	−0.27

[a] The final effect on GDP was estimated using a manufactures multiplier of 2.21.

To calculate this multiplier we estimate a model with eight sectors: mining, manufacturing, construction, electricity, commerce, transportation and communications, financial and other services. These sectors are linked in the model, and each sector is estimated with an equation. We use an error correction specification because these variables are non-stationary. The main exogenous variables of the model are industrial production and GDP in the U.S., public investment, public consumption, interest rate, and real exchange rate for Mexico (see Appendix B for details). The model allows us to obtain second-round manufacturing effects and to estimate the elasticity of Mexican GDP to changes in the manufacturing sector. We obtain an elasticity of manufactures with respect to total GDP of 0.37, implying a manufacturing multiplier of 2.21.[13]

We obtain the trajectory of GDP with and without gas shortages using the estimated effects of gas shortages on the manufacturing sector and the elasticity of GDP to changes in manufacturing. Table 4 and Fig. 7 present the estimate of the impact of natural gas shortages on national economic activity. The most serious effect of the shortages on GDP growth occurred during the second quarter of 2013, when the growth rate without shortages in seasonally adjusted quarterly terms, would have been −0.27%, rather than the observed −0.55%.[14]

It is important to mention that the main limitation of this estimation is that the model captures effects that last a maximum of two years. This model does not capture longer-term negative effects of the shortages like the disincentive the shortages may generate on direct investment, both, foreign and national and its consequences on GDP. Therefore, we can interpret these results as short-term effects only.

5. Conclusions

The Mexican economy suffered natural gas shortages from the first quarter of 2012 until the second quarter of 2013. In order to quantify the effect of these shortages on economic activity, we estimated a panel data model with month and state fixed effects. According to our preferred specification, an increase of 10 percentage points of shortage reduces manufacturing production by 0.32%. Shortages peaked during the second quarter of 2013, in this quarter GDP growth rate in seasonally adjusted quarterly terms would have been 0.28 percentage points higher if shortages had not occurred. These results suggest that gas shortages are a factor that contributes to explain the poor economic performance of the Mexican economy observed in 2013.[15] It is important to note that this study does not capture medium and long term effects of gas shortages. There is circumstantial evidence that investors delayed or canceled productive projects in Mexico due to uncertainty about gas availability (see El Informador (2013)). One of the main short-term measures to address the problem of gas shortages was the import of liquefied natural gas by sea via Manzanillo, a western coastal city (see Fig. 8). However, the price is considerably higher, which could have also had an adverse impact on production, though not of the same magnitude as the one associated with the gas shortage.[16] Also, the Federal Electricity Commission was affected by capacity restrictions in the pipeline infrastructure, which raised the cost of electricity generation. In the medium term, it will be necessary to expand the pipeline infrastructure. The new energy reform contemplates an ambitious program of investment in infrastructure with both public and private funding. *Los Ramones* project will both increase the natural gas provision to the mid-west region (see Fig. 8) and contribute to the resolution of the *bottleneck* problem (see Secretaría de Energía (2013)). It is crucial to advance this reform in order to reduce investors' uncertainty as to whether the expansion of the pipeline network will guarantee the timely supply of natural gas. Otherwise, investment in new productive projects could be discouraged.

In addition, one of the factors that contributed to gas shortages was a price-setting mechanism that appears to underestimate the real price of natural gas. Thus, further research is needed to evaluate whether if the government should subsidize gas infrastructure or whether consumers should bear the burden. The energy reform is silent about the price-setting mechanism and the subsidy question. An informed and transparent decision regarding these points is crucial to avoid future shortages. Private investment in natural gas transportation infrastructure has been permitted since the 1995 reform, but there has been virtually no such investment. Therefore, opening the energy sector to private investment does not in itself

[13] According to the The Manufacturing Institute (2012), the manufacturing multiplier in the U.S. is around 2.3.

[14] Note that in the first quarter of 2013 the growth with shortage is slightly higher than the growth without shortage. In this quarter shortages were not important. The fact that the X-12 seasonal adjustment procedure alters the growth path when there are changes in the original data could explain this observation. Yearly average growth, however, is higher in the scenario without shortages.

[15] During the first quarter of 2013, after the relatively good year of 2012 in which GDP grew by 3.6%, the average forecast for 2013 was 3.5% (see Consensus Economics (2013)). In the end, the growth in 2013 was only 1.06%.

[16] This suggest that a more efficient way to rationing natural gas would have been price — based rationing. However, this system has also disadvantages. For example, it requires a precise estimation of the price elasticity of the demand of natural gas. Furthermore, this price elasticity could change in time due to the adoption of new technologies that will alter the needs of the manufacturing firms.

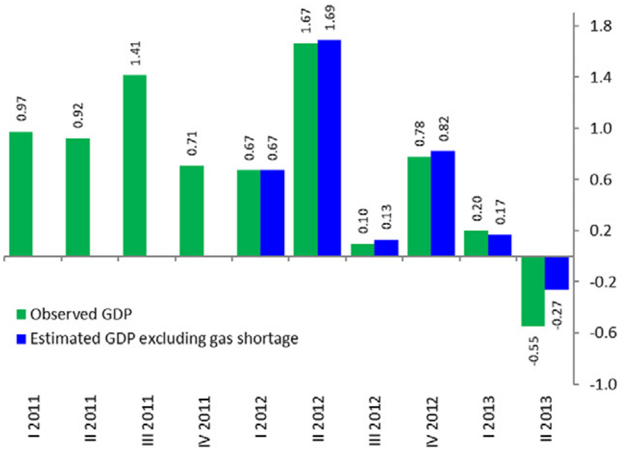

Fig. 7. Quarterly percentage change of total GDP. Seasonally adjusted series. Source: Authors' estimates with data from INEGI.

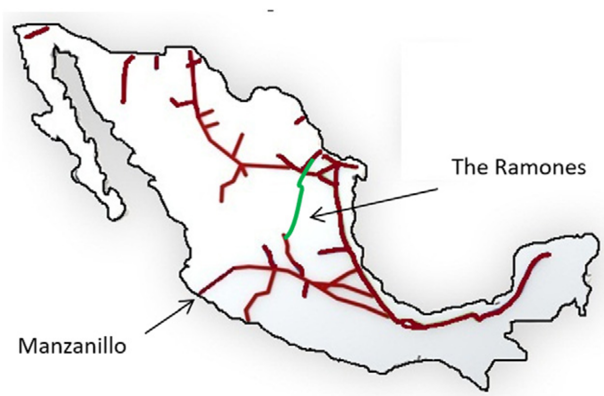

Fig. 8. Proposed scheme of the national gas pipeline system. Source: Presidency of Mexico, 2011.

guarantee efficient markets without shortages, if the price-setting mechanism is not correctly established.

These findings have important implications for economic policy for three reasons. First, they highlight the importance of a competitive and adaptable energy sector for economic growth in Mexico. Second, they contribute to a better understanding of the economic performance of the Mexican economy in 2013. Third, they highlight the importance of the current energy reform and rise issues like the price-setting mechanism that could potentially hamper the development of industry.

Appendix A. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.eneco.2017.06.006.

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