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# Empirical Evidence from Iranian Provinces

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**Sanctions and the Shadow Economy:**

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**Abstract**

Using Iranian-province-level data from 2001–2013, this study finds that the international sanctions of 2012/2013 had a significantly stronger negative impact on the growth rate of the shadow economy than they did on the official GDP growth rate. Thus, the international sanctions on Iran have damaged the informal economy even more than the formal economy.

## 1. Introduction

The US's and EU's 2012 energy and financial sanctions as a reaction to Iran's uranium-enrichment programme had significant effects on key economic indicators.[1] According to EIA (2018), daily oil production in Iran dropped by almost 17% in 2012 and by 9% in 2013, resulting in the lowest value since the end of the Iran-Iraq War in 1988. Furthermore, the exports of total petroleum products showed a drop of 32% in 2012 and a further decrease of 25% in 2013. Figure 1 shows the trend of Iran's daily oil production and exports during the government of Ahmadinejad (2005–2013) and parts of Rouhani's term of office (2013–present).

**Figure 1.** Production and export of total petroleum and other liquids in Iran (bbl per day)
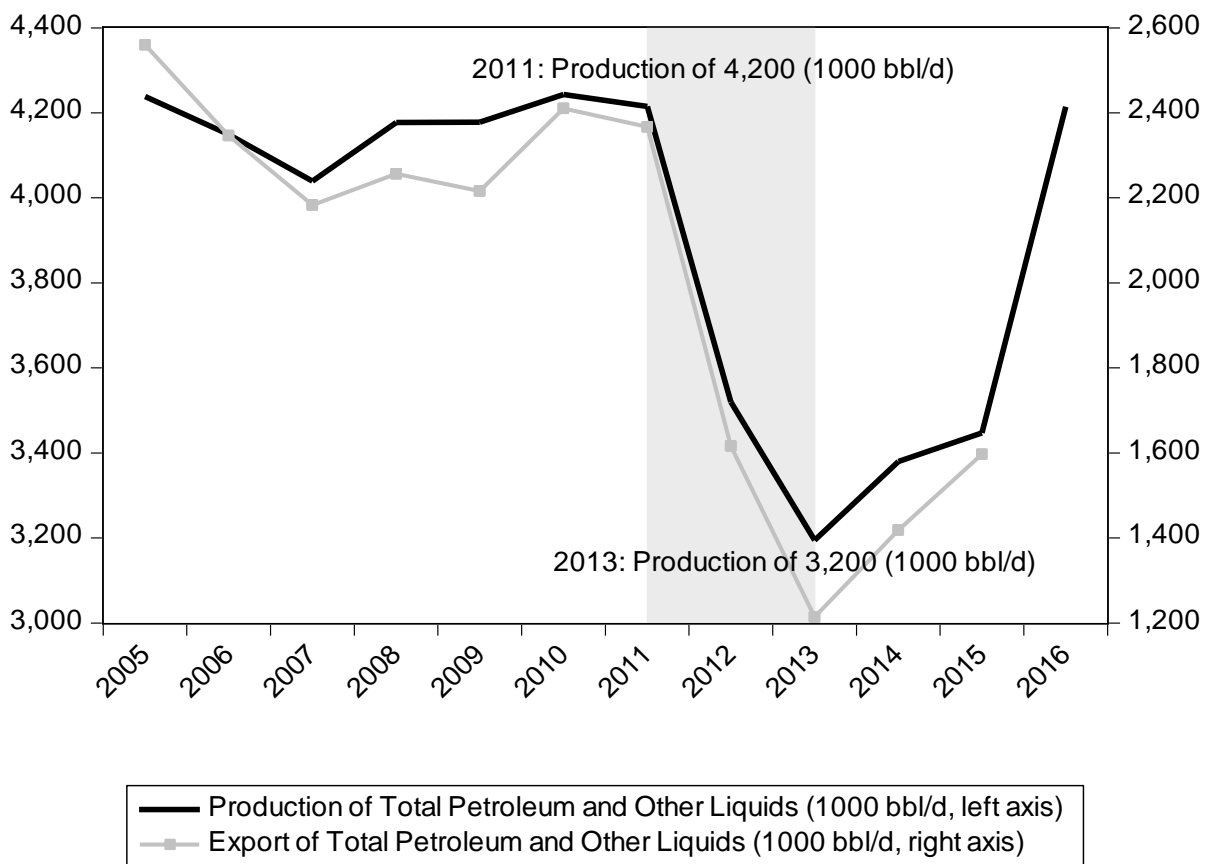


Source: EIA (2018).

The value of Iran's petroleum exports fell from $114 billion in 2011 to $101 billion in 2012 and to $61 billion in 2013 (OPEC, 2017). The average price of crude oil did not change notably during 2011–2013.[2] Due to Iran's strong dependence on the oil sector (Farzanegan and Markwardt, 2009), the 2012/2013 economic sanctions had a significant effect on the official economic growth rate. As illustrated in Figure 2, GDP per capita growth was negative in 2012 (–8.6%) and 2013 (–1.4%), bringing real GDP per capita down to about the level recorded in 2006.

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[1] For a detailed review of these sanctions, see Farzanegan (2013).
[2] The price (USD per bbl) was $111 in 2011/2012 and $109 in 2013 (EIA, 2018).

**Figure 2.** GDP (2010$, PPP) per capita growth rate in Iran (%)
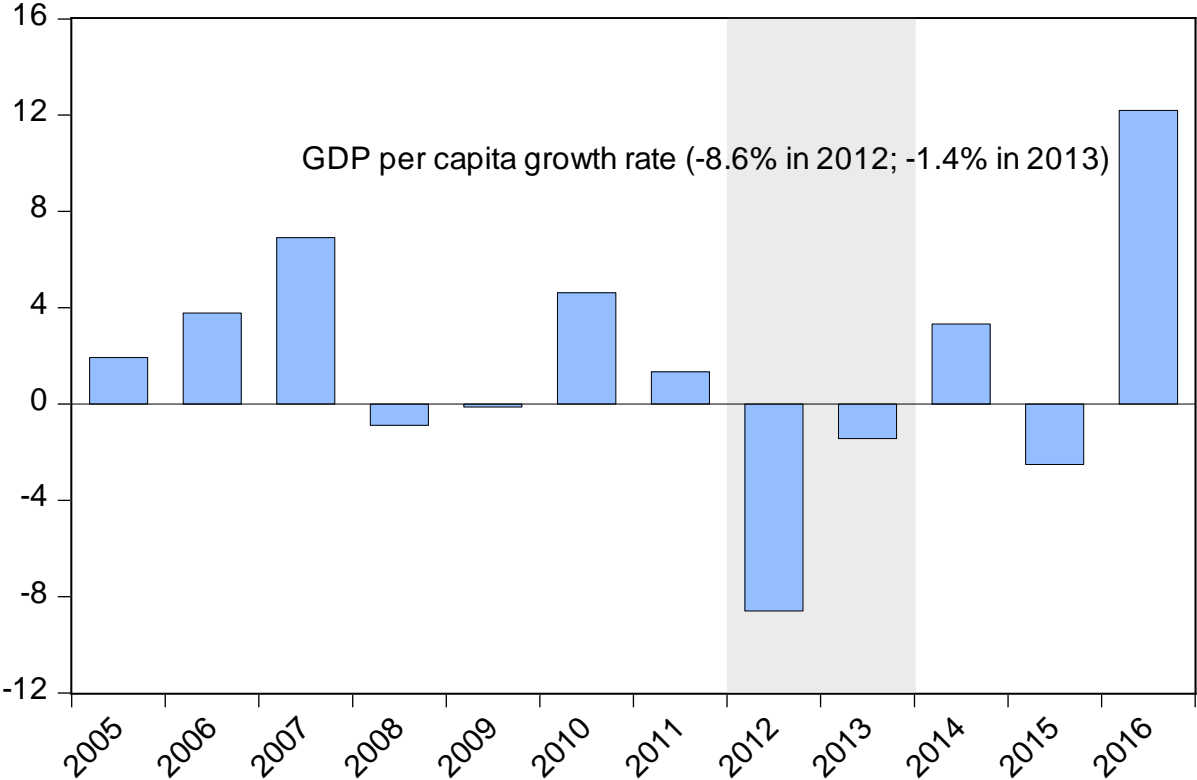


Source: EIA (2018).

Earlier case studies of Iran investigate the effects of international sanctions by looking at how oil revenue shocks impact government spending behaviour, imports, investment, income, and political institutions (Dizaji and van Bergeijk, 2013). Farzanegan (2013) provides a detailed description of the informal economy under sanctions. Here, we model the relative response to the 2012/2013 sanctions by the Iranian shadow (informal) economy compared to the reaction by the official economy. To measure shadow economy activity, we use information on night light intensity, which is available at the province level until 2013. Recently, researchers have begun using night light to extract information about the shadow economy (Medina and Schneider, 2017; Tanaka and Keola, 2017).

## 2. Data, Methodology, and Results

Modelling the shadow economy empirically is difficult and only very rough proxies are available. While night light data were originally employed as an indicator of GDP (Henderson et al., 2012), it is likely that shadow economic activity has a positive impact on the intensity of night light, too. Thus, night light contains two components—one related to officially measured economic activity and one related to the shadow economy—which creates an identification problem when using night light for studying the *level* of the shadow economy. We thus instead investigate whether the impact of sanctions is *relatively* stronger or weaker on the shadow economy compared to official GDP. Utilising Iranian regional data from 2001 to 2013, our dependent variable is the difference between the growth rates in night light and real GDP.

Employing growth rates has two other potential advantages. First, doing so renders our data stationarity. Although often neglected in panel studies, nonstationarity of variables can lead to spurious relationships when estimating panel regression models in the same way as it does in time-series models (Granger and Newbold, 1974). However, given the short time dimension in many panel datasets, including ours, panel unit root tests are unreliable. By taking first differences of our variables, we remove stochastic and deterministic trends from our data at a regional level. Second, we identify the effect of oil sanctions through a step dummy, which takes on the value of 1 in 2012 and 2013. Hence, the inclusion of time dummies to capture possible trends would lead to perfect multicollinearity. The main disadvantage of differencing is the loss of long-term information from our variables. We do not think this is a major problem here, however, as we are not concerned with long-term effects and, given the short time dimension, cointegration techniques would be unlikely to yield meaningful results anyway.

Our explanatory variables are ones often used in the literature on the shadow economy (Schneider and Enste, 2013): unemployment rate in %, consumer price inflation in %, share of agricultural value added in total value added %, share of industry value added in total value added %, and share of direct taxes in total value added.[3] These variables are transformed into their first differences. Estimation is made with various panel-data models. The left-side columns of Table 1 contain the general model in the form of a fixed effects model.

**Table 1:** Fixed effects estimation with dependent variable (growth of night light – growth of GDP, in %)

| | General model | | Reduced model | |
|---|---|---|---|---|
| | Coefficient | SE | Coefficient | SE |
| Oil sanction | - 30.5** | 3.48 | - 33.1** | 3.13 |
| $\Delta$Inflation rate | 1.26** | 0.21 | 1.30** | 0.21 |
| $\Delta$Unemployment rate | 1.53* | 0.60 | 1.52* | 0.60 |
| $\Delta$Share agricultural sector | - 0.87 | 0.58 | | |
| $\Delta$Share industrial sector | - 0.38 | 0.46 | | |
| $\Delta$Direct taxes | 0.33 | 1.89 | | |
| Lag 1 dependent variable | - 1.164** | 0.069 | - 1.168** | 0.069 |
| Lag 2 dependent variable | - 0.481** | 0.051 | - 0.484** | 0.050 |
| Constant | - 40.0** | 0.018 | - 0.401** | 0.018 |
| Number of observations | 210 | | 210 | |
| Number of regions | 30 | | 30 | |
| Model significance test | F(8,29) = 97.6** | | F(5,29) = 123** | |
| Test of regional dummies | $Chi^2(30)$ = 5762** | | $Chi^2(30)$ = 1059** | |
| Overall $R^2$ | 0.56 | | 0.55 | |
| AR test | N(0,1) = 0.40 | | N(0,1) = -0.18 | |
| Testing-down restriction | F(3, 172) = 0.75 | | n.a. | |

Notes: SE = standard error. White (1980) robust SEs are used. AR test is the Arellano-Bond (1991) autocorrelation test. * and ** indicate significance at a 5% and 1% level, respectively.

The model includes two lags of the dependent variable and does not suffer from autocorrelation. The impact of sanctions is estimated as significantly negative, that is,

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[3] A detailed description of the variables can be found in the Appendix.

sanctions have a relatively stronger effect on the growth rate of the shadow economy than on GDP growth. During the sanctions, the shadow economy grew by 30 percentage points less than the official economy, a highly notable effect. Relating the size of this effect to fluctuations in the growth differential during our sample period, as measured by the standard deviation (24.7), we discover that the impact of sanctions is somewhat higher than one standard deviation. Thus, the impact of the sanctions is large, albeit within reasonable limits.

To see whether our sanction dummy covering the years 2012 and 2013 is statistically meaningful, we split it up into two yearly dummies and include these in the model. We then test whether the estimated coefficients for the two yearly dummies are significantly different across each province; they are not ($F(1, 29) = 0.47$). Moreover, testing the difference between the dummies for 2012 and 2013 against those for 2010 and 2012 reveals a significant difference ($F(1, 29) = 22.5***$). Put differently, something unusual appears to have happened in the sanctions period compared to the preceding period. Thus, we find empirical support for the implicit restriction underlying the sanctions dummy.

For changes in inflation and unemployment rates, we discover the opposite effect. Increasing inflation and unemployment rates foster the development of the shadow economy relative to the official economy by 1.3 and 1.5 percentage points, respectively. These results are in line with theoretical priors and the extant literature (Mauleón and Sardà, 2017; Mazhar and Méon, 2017). The other explanatory variables are not individually significant.

We then derive a reduced model using a consistent general-to-specific modelling approach (Hendry, 1993), the results of which can be seen in the right-side columns of Table 1. The results for the testing-down restriction show that ΔShare agricultural sector, ΔShare industrial sector, and ΔDirect taxes have no explanatory power and that the insignificant t-tests in the general model are not due to collinearity. Our estimate of the impact of sanctions has increased slightly in absolute terms.

We conduct a number of robustness tests. First, due to the fewer number of variables in the reduced model of Table 1, 28 additional observations (13% more) become available and can be used for assessing the sanctions effect. The 'full sample' estimates in Table 2 show that the coefficient for the sanctions indicator remains significant at a 1 per cent level and changes from –0.33 to –0.30, thus indicating the robustness of our estimate.[4]

Second, instead of estimating fixed effects models, we could employ the potentially more efficient random effects model. However, the significance test of regional dummies in Table 1 already indicates that provinces are characterised by time-invariant differences in the dependent variable. Conducting a formal Hausman test reinforces this conclusion, as there is a significant difference between the coefficients from fixed and random effects models ($Chi^2(7) = 45.9**$).[5] Nevertheless, we estimate the reduced model using random effects, too. As can be seen in Table 2, the results remain almost unchanged.

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[4] However, note that due to the low standard errors, these coefficients are statistically significantly different at a 1 per cent level when using a t-test for equal means with unequal variances.
[5] Note that, by construction, the Hausman test is based on normal standard errors.

**Table 2:** Fixed effects estimation with dependent variable (growth of night light – growth of GDP)

| | Full sample | Random effects | GMM 1-step | GMM 2-step |
|---|---|---|---|---|
| | Coefficient | Coefficient | Coefficient | Coefficient |
| Oil sanction | - 30.1** | - 29.9** | - 34.5** | - 41.1** |
| $\Delta$Inflation rate | 1.16** | 1.11** | 1.35** | 1.90** |
| $\Delta$Unemployment rate | 1.49** | 1.44* | 1.46* | 3.83** |
| Lag 1 dependent variable | - 1.06** | - 0.99** | - 1.22** | - 1.53** |
| Lag 2 dependent variable | - 0.40** | - 0.35** | - 0.51** | - 0.73** |
| Constant | 38.9** | 36.6** | 43.0** | 28.0** |
| Number of observations | 238 | 238 | 210 | 210 |
| Number of regions | 30 | 30 | 30 | 30 |
| Model significance test | $Chi^2(5) =$ 414** | $Chi^2(5) =$ 282** | $Chi^2(5) =$ 893** | $Chi^2(5) =$ 422*** |
| Test of regional dummies | $Chi^2(30) =$ 1059** | n.a. | $Chi^2(30) =$ 3204** | $Chi^2(30) =$ 175** |
| Overall $R^2$ | 0.53 | 0.53 | n.a. | n.a. |
| AR test | N(0,1) = - 0.18 | N(0,1) = 2.93** | N(0,1) = - 3.5** | N(0,1) = 1.55 |
| Sargan test | n.a. | n.a. | $Chi^2(133) =$ 133 | $Chi^2(133) =$ 5.8 |

Notes: White (1980) robust standard errors (SEs) are used in the first two columns, robust SEs with Windmeijer (2005) small-sample correction in the case of two-step GMM. AR test is the Arellano-Bond (1991) autocorrelation test, of order 1 in the first two columns and of order 2 in the case of GMM. *, **, and *** indicate significance at a 10%, 5%, and 1% level, respectively.

Third, we use data in differences and thus the demeaning process underlying our fixed effects estimator should not create a correlation between lagged dependent variables and error. Moreover, as a political response to Iran's nuclear weapons research programme, our sanctions indicator should be completely orthogonal to the other variables. Thus, even if there was a Nickell bias (Nickell, 1981), it should not be relevant for our parameter of interest. However, due to certain characteristics of the data generating process, it could be possible that the lagged dependent variables estimated in Table 1 are inconsistently estimated. In addition, given that we rely on a step dummy in a small-sample environment, our identification scheme is weak. To exclude the possibility that Nickell biases play a role when estimating the effect of sanctions, we re-estimate the reduced model using the Arellano-Bond general method of moments (GMM) estimator (Arellano and Bond, 1991). We apply both one-step and two-step estimators, the results of which can be found on the right-hand side of Table 2. The sanctions indicator remains statistically significant, as do inflation and unemployment rates. The impact of the sanctions appears to be especially pronounced in the two-step estimated model compared to our other results. Still, we conclude that our results are remarkably stable across different econometric specifications and extensions of the sample size.

### 3. Conclusion

We show that the international sanctions imposed on Iran in 2012/2013 not only reduced the real GDP growth rate but also the growth rate of the shadow economy. We find that the absolute effect of sanctions on the shadow economy is statistically and economically much larger than the one on the official economy. Thus, sanctions can be considered a double burden on the Iranian population, since they also negatively affected the potential safety net offered by shadow economy activity.

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**Appendix**

**Data description**

| Variables | Definition and source |
|---|---|
| Shadow growth | Difference between the first differences of log(mean night-time luminosity) and log(GDP)<br>Source for night light data is https://datainspace.org/index.php/global-nighttime-lights-at-adm2-level-1992-2013/; and for regional GDP is SCI (2018) |
| Oil sanction | Sanction dummy (1 for years 2012 and 2013, 0 for the rest) |
| Inflation rate | First difference of logarithm of consumer price index<br>Source: MEFA (2018) |
| Unemployment rate | The ratio of the unemployed population to the active population (employed & unemployed) multiplied by 100 (in first difference)<br>Source: MEFA (2018) |
| Direct tax | First difference of share of direct taxes in total value added; direct taxes are levied on the revenues and assets of natural persons and legal entities before being transferred into provincial treasury accounts<br>Source: MEFA(2018) |
| Share agricultural sector | First difference of share of agricultural value added in total value added<br>Source: SCI (2018) |
| Share industrial sector | First difference of share of industry, mines, construction, and energy value added in total value added<br>Source: SCI (2018) |