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Potential early phase success and ultimate failure of economic sanctions: A VAR approach with an application to Iran

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Abstract

In order to explain why successes of economic sanctions predominantly occur in the first two years of a sanction episode, we analyse the dynamic economic and political impact of an economic sanction. Our theoretical analysis of the dynamics of adjustment gives us two important results: firstly, the strongest impact in terms of utility forgone occurs in the initial phase of the sanction episode and, secondly, the long-term gain of compliance decreases during a sanction episode and is lower in the long run than acknowledged by the usual comparative static analysis. On both accounts we expect that sanctions have a higher probability of success in the early phase and a lower probability of success in the long run. Next we build a comprehensive set of vector autoregressive (VAR) models that we apply to the case of a boycott of Iranian oil. An important innovation is that we include both economic and political factors in a VAR model of economic sanctions. Our VAR models find significant impacts of economic sanctions both on key economic variables (government consumption, imports, investment, income) and on two indicators of the political system (the Polity variable that describes shifts in the autocracy–democracy dimension and the Vanhanen Index of Democratization that describes political competition and participation). The impact of an oil boycott on the Iranian economy is considerable: oil and gas rents are important drivers of the Iranian key macroeconomic variables and ultimately of its political system. A reduction of oil and gas rents creates economic costs that act as incentives to move towards a more democratic setting. However, this effect is only significant in the first two years and turns negative after six to seven years, as adjustment of economic structures mitigates the economic and political impact of the sanctions.

Keywords

Iran, JEL: F51, sanctions, vector autoregressive model

Introduction

The first two years of a sanction episode are crucial for the success of economic sanctions. According to the Hufbauer et al. (2008) dataset, 55% of the successes (that is changes of behaviour or political regime type) occur during the first two years. The probability of success decreases substantially after this initial phase (Table I).[1] This stylized fact is at odds with the idea that total damage (which increases over time) is the driver of sanction success (Daoudi & Dajani, 1983);

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[1] Table I is bivariate and includes ongoing sanctions. Detailed multivariate logit analyses, however, do not find significant differences with respect to the impact of duration on sanction success in ended and ongoing sanctions, respectively; see van Bergeijk (2009: 131, Table 6.4).

Table I. Frequency distribution of duration of post-1945 sanctions

Duration	*Failures (%) (A)*	*Successes (%) (B)*	*Ratio (B/A)*
< 1 year	17	41	2.4
1–2 years	6	14	2.3
2–3 years	15	9	0.6
> 4 years	62	37	0.6
Total	100	100	

Totals may not add up due to rounding. Calculations based on Hufbauer et al. (2008).

it also indicates that the average annual damage of a sanction episode may not be an appropriate impact indicator despite its widespread use in empirical studies of the success and failure of sanctions. The longevity of sanction episodes has already drawn the attention of many authors. Patterns of success, failure, duration and termination of long-lived sanctions have been related to the target's and sender's institutional characteristics and the changes therein (Bolks & Al-Soyawel, 2000; McGillivray & Stam, 2004), commitment strategies (Dorussen & Mo, 2001) and Bayesian learning (van Bergeijk & van Marrewijk, 1995). This article adds to this literature as we offer a theoretical explanation and an empirical test of why success predominantly occurs in the early phase of a sanction episode.

We analyse the economic dynamics of an economy that is hit by economic sanctions since this enables us to distinguish early and later phases of a sanction episode in order to uncover the economic drivers of the empirical regularity that successes by and large occur in the early phase. We design a vector autoregression (VAR) model for Iran that focuses on dynamic economic adjustment and thereby allows us to analyse how economic variables influence political variables. Our methodology has its roots in economics (Sims, 1980) but is recognized as a useful approach in political science as well (Freeman, Williams & Lin, 1989), especially when it is important to distinguish the short-run and long-run impact of interventions (Enders & Sandler, 1993).

The contributions of this article are that we (i) develop a theory of dynamic economic adjustment in the context of sanctions, (ii) relate changes in sanction damage to regime evolution and (iii) build an econometric model in order to assess how economic sanctions affect Iranian macroeconomic and political conditions. We simultaneously investigate the impacts of economic sanctions on key economic variables (exchange rate, consumer price index, gross capital formation, government consumption, defense expenditures, imports and Gross Domestic Product (GDP)) and indices for the political system (in particular shifts in democratic and autocratic elements and changes in democratization, as operationalized by the Polity and Vanhanen indices, respectively). We find that these effects are limited in time and occur in the early phase of the sanction episode only, because economic adjustment mitigates the effects of the sanctions. One clear message for future research is therefore that students of economic sanctions should take the time profile of sanctions into account when discussing the potential usefulness and/or impact of economic sanctions as a tool of foreign policy.

Our empirical analysis is based on the historical responses of Iranian macroeconomic variables and the political system to the oil and gas rent shocks. We use this experience to analyse a shock that mimics the sanctions against Iran. Three factors motivate the choice of the country application. Firstly, recent autoregressive models are available for the main sectorial target of sanctions, namely Iranian oil exports (Dizaji, 2012; Dizaji et al., 2013; Esfahani, Mohaddes & Pesaran, 2012; Farzanegan, 2011; Farzanegan & Markwardt, 2009) so that the economic impact is well understood and less prone to discussion. Secondly, the current debate appears to be mainly qualitative and based on the interpretation of selected events (e.g. Maloney, 2009; Esfandiary & Fitzpatrick, 2011) and/or high profile sanction-busting incidents (e.g. Kozhanov, 2011). The debate on the merits of sanctions against Iran could thus benefit from an *empirical* analysis. Thirdly, the Iranian case *a priori* meets the key criterion for economic impact: that is, a sufficient level of pre-sanction trade linkage between sender and target (van Bergeijk, 1989, 2009). Figure 1, based on the most recent IMF estimates, shows substantially decreasing Iranian trade (so the sanctions are effective indeed). This 7.1 percentage points decrease (a reduction by one-third!) is stronger than could be expected on the basis of Iran's 2010/11 export-to-GDP ratio of 21% and the share of the EU and USA in Iran's exports of 18%, as these ratios in combination imply that trade at risk would be 3.8% of Iran's GDP. The EU financial sanctions that accompany the oil boycott may explain why the sanctions are biting much harder. These financial sanctions exclude Iran from the SWIFT worldwide messaging system used to arrange international money transfers, which makes international payments very difficult and also constrains other bilateral economic flows.

All in all, topicality and both theoretical and empirical relevancy motivate the choice for Iran as a case study. Note that while our *approach* is country-specific, our *findings* may well extend to other cases: Hufbauer et al. (2008) list 21 sanction cases that aim to change nuclear policies;

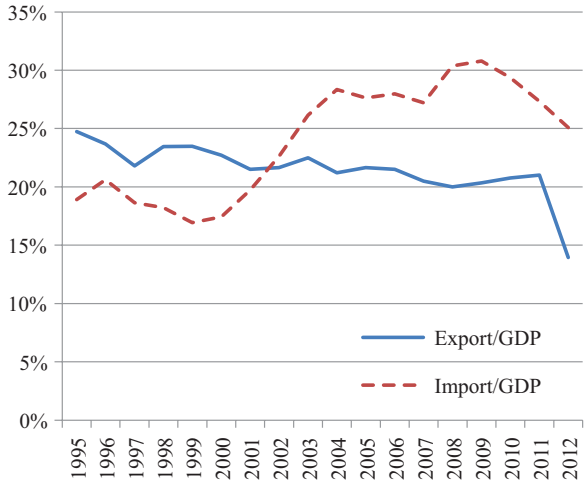

Figure 1. Export/GDP ratio and Import/GDP, Iran, 1995–2012, constant prices and exchange rates

Sources: GDP, exports and imports at constant 2000 prices and dollars for 1995–2007 are from World Bank, World databank (http://databank.worldbank.org, accessed 5 December 2012) and calculated from their real growth rates for 2008–12 as reported and estimated in IMF, October 2012 World Economic Outlook database (http://www.imf.org/external/pubs/ft/weo/2012/02/weodata/index.aspx, accessed 5 December 2012).

six cases are successful and the median durations for successes and failures are one year and four years, respectively.

The next section develops a theory that relates sanction effectiveness (sanction damage) and sanction success (compliance with the sanction sender's objective). We discuss economic and political theories that relate sanction damage to sanction success. Our aim is to show how economic adjustment over time changes damage and thereby influences the political impact of sanctions. We use the neoclassical trade model to clarify (i) that sanction damage is largest in the early phase of the sanction episode and (ii) that in the long run the target's economic benefits of compliance decrease. Both these points have been overlooked as theories have by and large relied on comparative statics. Next we deal econometrically with these issues for the case of Iran. We set out the research design and present the empirical results using impulse-response functions and variance decomposition to show the development of the variables over time. Since one important novelty of this article is the inclusion of a political variable in a model of economic sanctions, we present the analysis both for the Polity and the Vanhanen indices.

Short-run and long-run impact of sanctions

We start the analysis in the usual comparative statics context that provides the main analytical economic framework since its introduction by Kemp (1964: 208–217; see also Porter, 1979; Frey, 1984). For ease of exposition we analyse the case of a sanction that cuts off all trade, but our qualitative results also hold for less extreme cases. The comparative static economic analysis sees the long-run loss of the gains from free trade as the main determinant for a change of behaviour of the target. In a nutshell the economic approach is that the target makes a cost–benefit analysis of the options 'comply' and 'not comply' and will not comply if free trade utility U_F is less than non-compliance utility U_{NC}. Non-compliance utility consists of autarky (no trade) utility U_A and the utility that the target of economic sanctions derives from the activity that the sanctioning economy opposes U_O and wants to end or deter (so we have $U_{NC} = U_F + U_O$). Admittedly, it is not always easy to quantify this utility, but many forms of non-compliance have a clear economic dimension. Examples include expropriation, illegal occupations of territory and possession of and capacity to build weaponry. However, even in cases where the opposed activity is intangible and does not seem fit for the measuring rod of money, the basic principle applies that sanctions that (threaten to) restrict international trade reduce the utility of non-compliance and thereby can change the target's behaviour.

Economic damage and political impact

While the neoclassical trade model offers a powerful tool to analyse sanction damage, the implicit assumption of a rational unitary actor that makes a cost–benefit analysis for society as a whole and acts accordingly is rather simplistic, although it may be appropriate when, for example, sanctions threaten the target's military power. Moving beyond the unitary actor model Kaempfer & Lowenberg (1988) pioneered the public choice approach to economic sanctions in which interest group competition and political institutions are important determinants of sanction result. This focuses attention on the extent to which sanctions hurt the supporters of the target government directly or compromise that government's ability to reward supporters or suppress opposition (Escribà-Folch, 2012).

Marinov (2005) develops a theory that links economic activity to the likelihood that the target's leadership will survive. Typically growth slowdowns are associated with higher political turnover. The sanctions may either help to replace the target's government or open up a bargaining range making the target's leadership more willing to compromise due to increasing political costs of not complying (that is, a higher likelihood of government turnover).

Importantly, Marinov tests his theory empirically, finding that it is the rate of economic growth rather than the level of economic wealth that determines the leader's survival in office.[2] The key point is that the change in economic wealth matters empirically and therefore we take a closer look at the evolution of sanction damage during a sanction episode.

Sanctions in the neoclassical trade model

Figure 2 illustrates the neoclassical trade model. The production possibilities curve *I* shows the maximum attainable production (combinations of goods *x* and *y*) given the available endowments and technology. Consumer preferences are depicted by a selection of three convex indifference curves, C_1, C_2 and C_3, each representing combinations (x, y) that yield a constant level of utility. The figure contains two price ratios: p_A that results in autarky (that is, if the economy does not trade) and ratio p_W, the given world price. The 'autarky' point *A* gives long-run production and consumption in the hypothetical case that the target economy cannot trade with other countries, as in the case of a complete sanction. Markets are in equilibrium: in *A* the producers' rate of transformation (the tangent to *I*) equals the consumers' marginal rate of substitution (the tangent to the indifference curve) and *x* and *y* are exchanged against price ratio p_A. Point *F*, the free trade point, is the pre-sanction consumption point (at a superior utility level of C_3); the concomitant production point is point *D* (exports and imports are the difference between *D* and *F*).

The traditional comparative analysis of sanctions is as follows. Let U_O be the utility that the target derives from the objected activity that the sender seeks to discourage. The comparative static analysis states that the target will comply if $U_F > U_A + U_O$. By implication sanctions in the comparative static framework will work either directly ($U_F > U_A + U_O$) or never ($U_F < U_A + U_O$).

The economic dynamics of sanctions

Moving beyond comparative statics, Figure 2 clarifies the different phases of a sanction episode. A non-sanctioned, fully specialized economy will produce at *D.* Point *D* is thus the production point directly after the imposition of sanctions, because the factors of production were used in specific combinations and their reallocation takes time. By necessity consumption therefore drops to *D*,

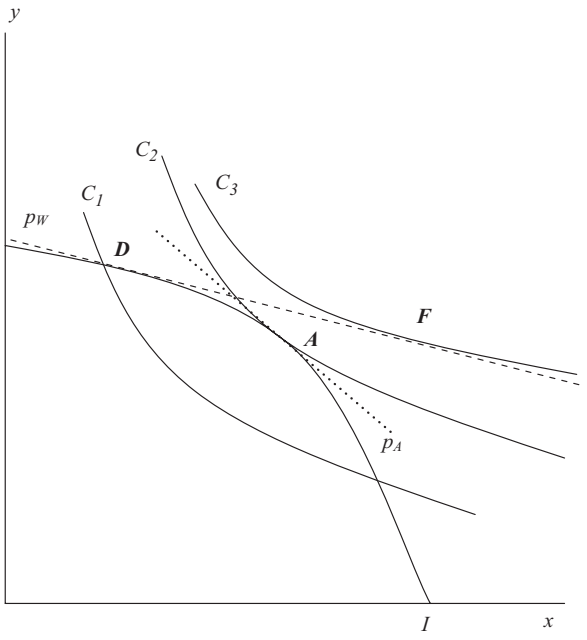

Figure 2. Production, consumption and specialization at different stages of international trade

that is, the production mix that was produced at the end of the pre-sanction period. Since this production combination is the result of decisions that assumed that international trade would be possible, the resulting consumption combination logically cannot be optimal if trade is impossible. The extent of specialization being suboptimal, this situation yields lower utility than in autarky. Since the rate of transformation in *D* is not equal to the marginal rate of substitution, consumers are willing to exchange *y* for *x* and the price of *x* increases. The production pattern adjusts, the economy despecializes and more *x* will be produced until prices settle at p_A in *A*. The time path of utility (Figure 3; solid line) directly relates to the consumption possibilities in the economy and shows an abrupt drop from u_F to u_D at time *T* when the sanction is imposed and then a gradual movement towards u_A reached at time *a*.

Specialization and despecialization, however, do not only impact on the dynamics of the no trade utility level but also influence free trade utility. A despecializing economy will have to respecialize and thus will have to bear the future costs of adjustment towards free trade as well. We should reformulate the condition for sanction success: the target will not comply if the net present value (NPV) of the stream of future free trade utility is less than the NPV of the stream of non-compliance utility (consisting of autarky utility and utility derived from non-compliance). Both streams are influenced by adjustment and the future costs of an

[2] Likewise Svolik (2008) finds that authoritarian reversals are associated with economic recessions, but not with the level of economic development.

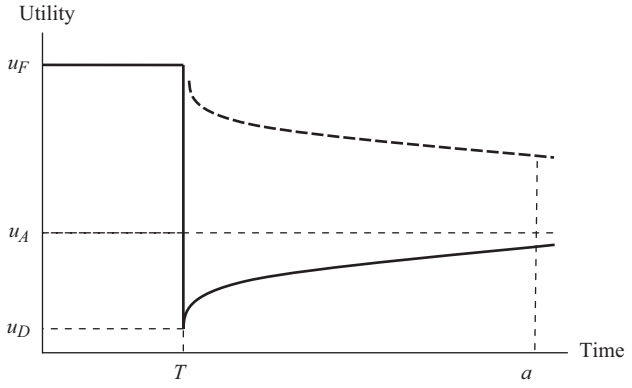

Figure 3. Time path of utility as the economy moves from free trade to autarky due to a sanction

ongoing sanction.[3] Consider the moment when adjustment is almost complete, as at time *a* in Figure 3. The target will consider the NPV of the future stream in case of non-compliance, equal to $(U_A + U_O) / i$ where i is the discount rate and compare this to the NPV of compliance but now taking the costs of adjustment into account (Figure 3; dashed line) and this is less than U_F / i.

Our analysis of the dynamics of adjustment thus provides two important results. The strongest impact in terms of utility forgone occurs in the initial phase of the sanction episode. The long-term gain of compliance decreases during a sanction episode and is lower in the long run than acknowledged by the comparative static analysis. On both accounts we expect that sanctions have a higher probability of success in the early phase and a lower probability of success in the long run. The next sections empirically investigate the validity of this hypothesis.

Research design

The key issue in this article is the interplay of macroeconomic and political variables and how these factors determine the result of sanctions. Over 2007–11 on average 83% of Iranian exports, 34% of Iranian government revenues and 24% of Iranian GDP directly related to the main target of the sanctions: the Iranian oil industry (CBI, 2012). For practical reasons we model the sanctions as a shock to real oil and gas rents per capita. From the macroeconomic perspective we are interested in the impact of this shock on consumer prices, the real exchange rate, real imports per capita, real government consumption per capita, real capital formation per capita and real GDP per capita. From the political perspective we want to know if and how changes in these macroeconomic variables influence the Iranian institutional context with regard to the dimension autocracy–democracy and the extent of democratization.

We use different metrics in order to check the robustness of the empirical findings regarding the political system. Firstly, we use Polity IV that describes combinations of autocratic and democratic characteristics of the institutions of government (Marshall, 2011). Subtracting the autocracy score from the democracy score yields a summary measure *Polity*. This variable detects shifts in the autocracy–democracy dimension caused by changes in the qualitative aspects of institutions: a shift towards more democracy can be caused by a lower score for the subcharacteristic autocracy, a higher score for the subcharacteristic democracy or by any combination where the increase (decrease) of democracy is larger (smaller) than the increase (decrease) of autocracy. Next we use as an alternative the Vanhanen index of democratization that is defined as the product of two underlying indices for political competition and political participation (Vanhanen, 2011). Since the modelling of a sanction impact on the regime (change) is a key issue of our analysis (and also because this to our knowledge is the first time that economic and political factors are combined in a VAR model of sanctions), it is important that these measures do not only differ conceptually, but that their measurement also differs (Polity scores are subjective/judgemental while Vanhanen deploys numerical voting records). Consequently, the two indicators show different patterns of variation.[4] Using both metrics we will investigate the robustness of our findings.

Admittedly, the formally stated goal of the sanctions against Iran is to stop nuclear proliferation, but commentators have also linked the sanctions to democratization:

> The new US consensus on Iran favors economic sanctions, preferably 'crippling' measures that target Iran's purported Achilles' heel, primarily as a means to derailing an Iranian nuclear weapons capability, but also with hope of facilitating a democratic breakthrough. (Maloney, 2009: 132; see also Farzanegan, 2011: 19)

From this perspective polity (that is the net impact in the democracy–autocracy continuum) and political competition and participation are relevant. Our political variable covers both the Sanction–Democracy relation evident already in the work of Galtung (1967) and the

[3] Compare Nooruddin (2010: 71): 'once a sanction is imposed, the target must decide to resist or concede each year' and van Bergeijk & van Marrewijk (1995).

[4] We owe this point to an anonymous referee.

Sanction–Repression link recently explored by Peksen & Drury (2009, 2010).

We investigate the response of the macroeconomic and political variables to the sanction shocks deploying a set of unrestricted VARs. Like Peksen & Drury (2009) we set the simulation period at ten years (long run) but in contrast we use the first two years of the simulation to determine short-term effects (rather than their short-run period of five years that we consider to be medium term). The VAR treats all variables as jointly endogenous and does not impose *a priori* restrictions on structural relationships. This is helpful for our research because we do not need to specify *a priori* the structural interrelationships between politics and economics (and vice versa) in a sanction case (Pindyck & Rubinfeld, 1991). All that we need is a specification of the chain of influence between the variables and here we rely on theory and information of descriptive and analytical studies, including the country specific modelling exercises mentioned earlier.

Obviously many economic variables are relevant and ideally one would include all those variables. Unfortunately only annual data for a limited time range are available. Therefore we have only 48 annual observations (1959–2006 inclusive).[5] So we have to be parsimonious. This means that our method runs the risk of suffering from omitted variables bias. To avoid this problem as far as possible we follow the approach pioneered by Christiano, Eichenbaum & Evans (1996) and Jansen (2003) before we move on to a more comprehensive model. They analyze a set of separate VARs that always include the starting variable and the result variable, but use different sets of transmission variables. Our starting variable is oil and gas rents per capita. We consider this to be the most exogenous among the variables, because oil prices and consequently oil rents are determined by world market conditions and we expect that significant shocks in per capita oil and gas revenues affect the other key macroeconomic variables. Our result variable always is *Polity* or *Vanhanen*. We always include one key macroeconomic variable (either imports or government consumption) that we combine with other variables (government consumption or imports or gross fixed capital formation or GDP or the real exchange rate or the consumer price index). We always include *Polity* or *Vanhanen*, because we want to investigate if and how changes in the macroeconomic variables influence the target's political regime.

Table II illustrates our conceptualization. We estimate 20 separate VAR models based on two different measures for political impact (*Polity* and *Vanhanen*), a measure for the sanction shock, and five economic variables that are entered separately in the VAR models. We report the empirical results in the next section. Then based on these findings, we select the variables to be included in two more comprehensive VARs that we again subject to robustness testing (all data and econometric details are reported in the online appendix).

Choice and sequence of variables

The starting point is the oil boycott that is modelled as a shock in oil and gas rents per capita. This way of operationalizing is in line with recent VAR models on the Iranian economy in the context of economic sanctions (Dizaji, 2012; Farzanegan, 2011). We expect that significant shocks in oil revenues and rents affect contemporaneously the other key macroeconomic variables and the political variable.

Next we need to motivate the choice of the key economic variables to be included in the VARs. We will present two variants: imports per capita and government expenditures per capita. Providing two variants enables us to demonstrate robustness of the key findings.

Government expenditures. The common practice in recent VAR modelling of the Iranian economy (Dizaji, 2012; Farzanegan, 2011; Farzanegan & Markwardt, 2009) is to use government consumption expenditures (including current consumption, rents and depreciation) as a shock variable. Current expenditures (government salaries, subsidies, etc.) are seen as necessary expenditures for preserving the current capacities of government administration. Indeed, a large and growing public sector wage bill reflects the government's dominant economic role, especially since the 1979 Islamic Revolution. Subsidies also are important for the size and inflexibility ('hysteresis') of current expenditures: the Iranian government, the main recipient of oil and gas rents, redistributes part of the revenues through different kinds of subsidies. The inflexible structure of government expenditures implies substantial exogeneity with respect to other 'downstream' variables. Recent analysis (Farzanegan, 2011), however, indicates that the impact of oil revenues on different categories of government expenditures is limited (actually the only significant impact in his research is on military expenditures). Therefore we also

[5] Data on real oil and gas rents and defence expenditures are the limiting factors. Note that Dizaji & van Bergeijk (2012) demonstrate additional testing for real oil revenues 1965–2008 (44 observations).

Table II. Conceptualizations of the VAR

Beginning of the process	*Economic impact*	*End of the process*
Oil revenue shock	*Macroeconomic variables*	*Political variable*
Real oil and gas rents per capita	1. Imports per capita 2. Government consumption per capita *or* gross fixed capital formation per capita *or* GDP per capita *or* real exchange rate *or* consumer price index	Polity or Vanhanen index
Real oil and gas rents per capita	1. Government consumption per capita 2. Imports per capita *or* gross fixed capital formation per capita *or* GDP per capita *or* real exchange rate *or* consumer price index	Polity or Vanhanen index

consider imports as an alternative channel that influences the Iranian economy.

Imports. The reason to include imports is straightforward. Imports are rationed (they are *Q*-sanctions or quantity constraints in Spindler's (1995) terminology): changes in the other variables cannot increase imports beyond that rationed level. The rationing is an immediate consequence of the boycott that reduces the availability of foreign currency and this will by necessity lead to a reduction of imports in a hard currency constrained economy such as Iran.[6]

Further downstream. Both imports and government expenditures have an impact on the quality and quantity of new capital goods. In the longer run this reduces the Iranian production capacity. All factors (reduced government expenditures, reduced gross capital formation, reduced production and reduced imports) inject scarcity into the economy and this will influence relative prices. Two important macroeconomic variables take these effects into account. Firstly, the general price level (*Consumer Price Index*) may reflect 'black market' effects as in Spindler (1995), or scarcity of import products due to a lack of export revenues as in van Bergeijk (1994) and Eyler (2012). Secondly, the *real exchange rate* measures the ratio at which Iranian goods trade against the goods of the rest of the world. Sanctions limit the availability of foreign goods and if sanction busting occurs a premium needs to be paid (MacDonald & Ricci, 2004). In addition, as suggested by Sobel (1998), the real exchange rate reflects uncertainty and country risk due to sanctions and shifts in political institutions.

Political impact. All in all sanctions reduce government expenditure and investment, imply lower income, and deprive the economy of (some of) the gains from international trade. These economic losses influence the target's behaviour as discussed earlier. The economic variables ultimately impact on the political system leading to shifts in the underlying (autocracy and) democracy scores of Polity and the Vanhanen index.

Econometric issues

We use the VAR model to estimate the interrelationships among our variables. The VAR provides a multivariate framework relating changes in a particular variable to changes in its own lags and to changes in (the lags of) other variables:

$$y_t = A_1 Y_{t-1} + \ldots + A_p y_{t-p} + Bx_t + \epsilon_t \qquad (1)$$

where y_t is a vector of k endogenous variables, x_t is a vector of d exogenous variables, $A_1, \ldots, A_p$ and B are matrices of coefficients to be estimated, and ε_t is a vector of innovations that may be contemporaneously correlated but are uncorrelated both with their own lagged values and with all of the right-hand side variables.

We define the vector of exogenous variables as $x_t =$ [constant, D_1, D_2], where D_1 and D_2 are dummy variables capturing the 1979 Islamic Revolution and the Iran–Iraq war (1980–88), respectively. Since only lagged values of the endogenous variables appear on the right-hand side of the equation, simultaneity is not an issue and OLS yields consistent estimates.

We opt for an unrestricted VAR models in levels. Firstly, structural VAR models are 'very often misspecified' (Tijerina-Guajardo & Pagán, 2003). Secondly, the Phillips-Perron unit root test indicates that all variables are $I(1)$. Since all the variables are non-

[6] The target economy has some temporary leeway in running down international reserves and in theory could borrow on the international capital market. For Iran this is unrealistic given the international payments sanctions.

stationary, it is better to use a VAR in levels (Fuller, 1976). Thirdly, in the short term, which is especially important in our analysis, an unrestricted VAR performs better than a cointegrated VAR or Vector Error Correction Model.[7]

Data sources

The following variables are extracted from the Central Bank of Iran (CBI) online database and expressed in constant 1997 prices: real oil and gas rents, real government consumption expenditure, real defence expenditures, real imports, real GDP and real gross fixed capital formation. These variables are expressed in per capita terms and in logarithmic form. The consumer price index is from IMF *International Financial Statistics*. The real exchange rate is the official US dollars rate expressed in Iranian domestic prices (extracted from CBI) and divided by the respective consumer price indices (CPIs). The Vanhanen index is taken directly from the Finnish Social Science Data Archive (Vanhanen, 2011). We use the so-called *Polity2* variable available at the website of the Polity IV Project, since we analyse changes in regime in a time-series context (Marshall, 2011).

Empirical results

Our main tools are the impulse response functions (IRF) and variance decompositions. IRFs enable us to study the dynamic responses of the macroeconomic and political variables to sanction shocks. With the IRFs, we can observe both the magnitude and statistical significance of such responses to one standard deviation shock in the oil market related variable (Stock & Watson, 2001).

Table III summarizes the results for the 20 estimated VARs. The IRFs trace out the response of current and future values of the variables in the system to a one standard deviation decrease in the current value of real per capita oil and gas rents. Table IIIa reports on VARs that use *Polity* as the result variable, and Table IIIb reports on VARs that use *Vanhanen*. The upper part of the tables reports VAR variants that include per capita imports and the bottom part reports on VARs that include per capita government expenditures. Each line in the tables represents a different specification of the VAR and reports on the sign and significance of impact according to the IRFs.[8] We report the short term (the effect in the second year after the initial shock), the medium term (the effect in the fifth year) and the long run (ten years after initial shock). For example, the first line in Table IIIa states that imports are reduced due to the sanction shock, but this effect is not significant. In this VAR the intermediate variable is government expenditure per capita which also shows a decline in the different subperiods; the effect is significant in the short and medium terms. The change in *Polity* is positive in the short and medium terms (representing a move towards a more democratic framework) and negative in the long run. This change in *Polity* does not meet our requirements for significance. The first line of Table IIIb reports a similar pattern for the VAR that deploys *Vanhanen* (note that the reduction of imports per capita is now significant in the short term).

The information uncovered in the 20 VARs supports the following robust conclusions:

- We find strong and consistent evidence for an initially significant negative economic impact of sanctions that wanes at the end of the simulation period for government consumption per capita, imports per capita, gross capital formation per capita and GDP per capita.
- The evidence for the impact of sanctions on the consumer prices level and the real exchange rate is weak at best (no significance).
- The impact on *Polity* and *Vanhanen* is consistent, showing in most of the cases a development from positive to negative, and in the other cases a change in the same direction (from positive to nil). Significant improvements in the political indicators are only observed in the short term.

These three stylized facts imply that the political impact of sanctions, although (occasionally significantly) positive in the short term, deteriorates in the long run.

Extended VAR and variance decomposition

As we considered only a limited number of variables we may run the risk of omitted variables bias. In order to address this

[7] Naka & Tufte (1997) demonstrate that the loss of efficiency from VAR estimation is not critical for the short horizon. Engle & Yoo (1987), Clements & Hendry (1995) and Hoffman & Rasche (1996) show that an unrestricted VAR is superior in terms of forecast variance to a restricted VEC model on short horizons. Also see Farzanegan & Markwardt (2009: 139).

[8] We determine significance using standard procedures calculating 68% confidence bands around the IRF (Sims & Zha, 1999) and report significance if the null hypothesis of no effects of impulse variable shocks on the specific variable can be rejected (Berument, Ceylan & Dogan, 2010).

Table IIIa. Impact of sanction shock: VARs with Polity as the result variable

Intermediate variable	*Intermediate*			*Imports per capita*			*Polity*		
	Short run	*Medium*	*Long run*	*Short run*	*Medium*	*Long run*	*Short run*	*Medium*	*Long run*
Government consumption per capita	**Negative**	**Negative**	Negative	Negative	Negative	Negative	Positive	Positive	Negative
Gross capital formation per capita	**Negative**	Negative	Negative	Negative	Negative	Negative	**Positive**	Positive	Nil
GDP per capita	**Negative**	**Negative**	Negative	**Negative**	Negative	Negative	**Positive**	Positive	Nil
Exchange rate	Nil	Negative	Positive	**Negative**	Negative	Negative	**Positive**	Positive	Nil
CPI	Negative	Negative	Negative	Negative	Negative	Negative	Positive	Positive	Negative
Intermediate variable	*Intermediate*			*Government consumption per capita*			*Polity*		
Imports per capita	**Negative**	Negative	Negative	**Negative**	**Negative**	Negative	Positive	Positive	Negative
Gross capital formation per capita	**Negative**	Negative	Negative	**Negative**	Negative	Negative	Positive	Positive	Negative
GDP per capita	**Negative**	**Negative**	Negative	**Negative**	**Negative**	Negative	Positive	Positive	Nil
Exchange rate	Negative	Nil	Positive	**Negative**	**Negative**	Negative	Positive	Positive	Nil
CPI	Negative	Negative	Negative	**Negative**	**Negative**	Negative	Positive	Positive	Negative

Table IIIb. Impact of sanction shock: VARs with Vanhanen index as result variable.

Intermediate variable	*Intermediate*			*Imports per capita*			*Vanhanen index*		
	Short run	*Medium*	*Long run*	*Short run*	*Medium*	*Long run*	*Short run*	*Medium*	*Long run*
Government consumption per capita	**Negative**	**Negative**	Negative	**Negative**	Negative	Nil	Positive	Positive	Negative
Gross capital formation per capita	**Negative**	Negative	Nil	**Negative**	Negative	Nil	Positive	Nil	Negative
GDP per capita	**Negative**	**Negative**	Negative	**Negative**	Negative	Negative	Positive*	Positive*	Negative
Exchange rate	Negative	Negative	Nil	**Negative**	Negative	Negative	Positive	Positive	Nil
CPI	Negative	Negative	Negative	**Negative**	**Negative**	Negative	Positive	Positive	Negative
Intermediate variable	*Intermediate*			*Government consumption per capita*			*Vanhanen index*		
Imports per capita	**Negative**	Negative	Nil	**Negative**	**Negative**	Negative	Positive	Positive	Negative
Gross capital formation per capita	**Negative**	Negative	Negative	**Negative**	Negative	Negative	Positive	Positive	Negative
GDP per capita	**Negative**	**Negative**	Negative	**Negative**	**Negative**	Negative	Positive	Positive	Negative
Exchange rate	Negative	Negative	Positive	**Negative**	**Negative**	Negative	Positive	Positive	Negative
CPI	Positive	Negative	Negative	**Negative**	**Negative**	Negative	**Positive**	Positive	Negative

Significant deviations in **bold.** *Significant in 3rd year only. Short run $\leq$ 2 years; medium 3–5 years; long run 6–10 years.

problem we will specify a VAR model that includes all variables that are supported by the previous findings and provide alternative specifications at the end of this section. We do not include CPI and exchange rate in view of their weak performance in all variants and report the results for extended models with *Polity* and *Vanhanen*, respectively.

Impulse response functions

We have the following Cholesky ordering in our VAR system: real oil and gas rents per capita, real government consumption per capita, real imports per capita, real gross capital formation per capita, real GDP per capita, *Polity* or *Vanhanen*. This ordering indicates that oil and gas rents have an influence on government consumption expenditures and later on all other variables in the model. Oil and gas rents basically depend on world market conditions so their behaviour is the least determined by the other, national variables that we include in the model. The previous section clarified that government expenditures (a) are strongly influenced by oil shocks and (b)

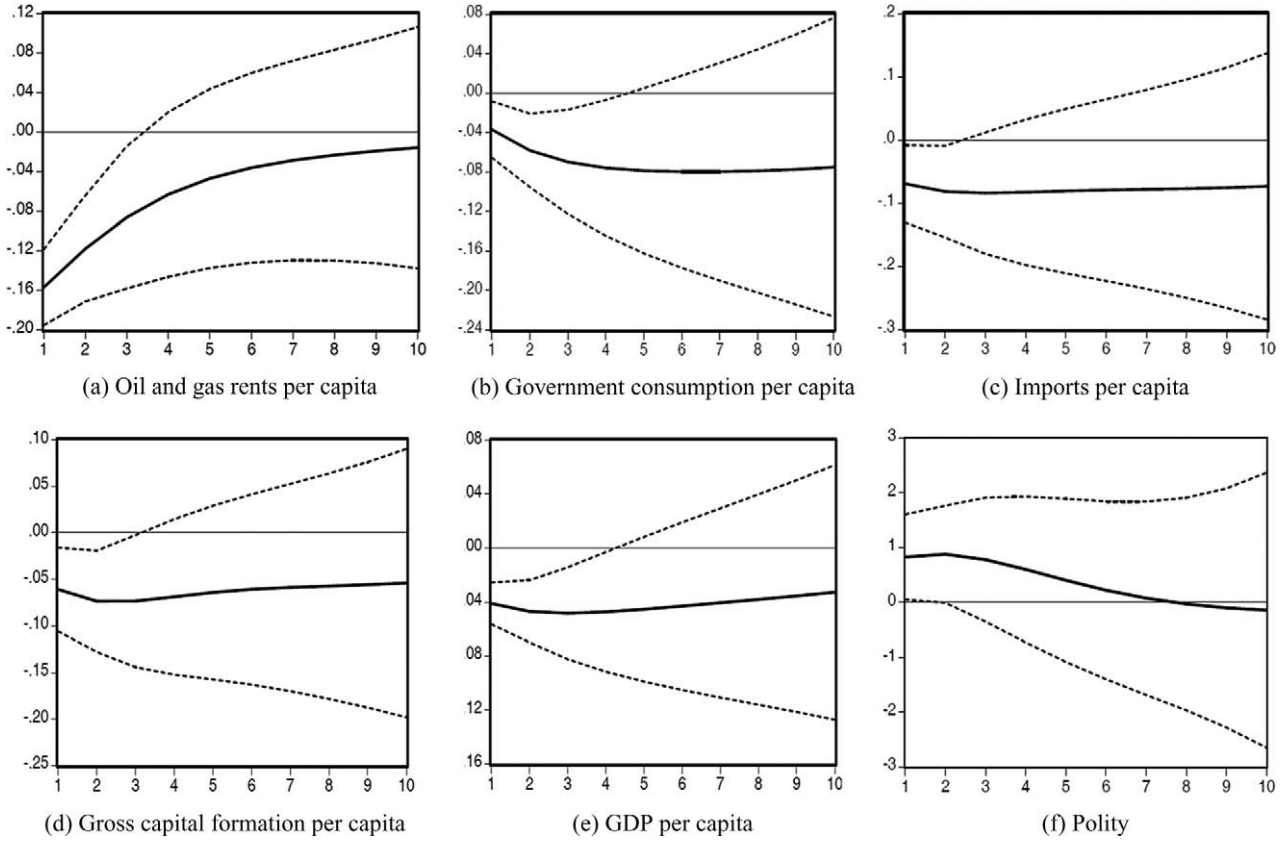

Figure 4. VAR responses to a shock in real oil and gas rents per capita (model with Polity)
All variables (except Polity) are in logarithmic form and real terms.

transmit the effects of sanctions to other macroeconomic variables significantly, hence their second position in the Cholesky ordering.[9] The negative development in oil and gas rents reduces the sources for financing imports and for investment projects. These changes influence GDP per capita and ultimately the changes in the economic variables affect polity and democracy.

Figures 4 and 5 report the IRFs that trace out the response of current and future values of the variables in the system to a one standard deviation decrease in the current value of real oil and gas rents per capita for the VARs with *Polity* and *Vanhanen*, respectively. The figures illustrate the impact of a sanction. This shock is accompanied by, on the one hand, initially negative and statistically significant responses in oil and gas rents per capita, real government consumption expenditures per capita, real imports per capita, real gross capital formation per capita and real GDP per capita and, on the other hand, an initially significantly positive response in *Polity* and *Vanhanen*, respectively. The figures tell similar stories for the time paths of the adjustment processes although occasionally small differences occur. Real government consumption expenditures per capita decrease for 3 to 4 years before recovering (after 4 years the impact is also no longer significantly different from zero). Real imports per capita decrease for 2 to 3 years; after the 3rd year the impact is no longer significant. Real investment per capita decreases for 2 to 3 years and then become insignificant. Real GDP per capita decreases for 3 to 4 years and thereafter becomes insignificant. Finally, we see that the sanction shock has a significantly positive short-term effect on *Polity* and *Vanhanen* that turns into an increasingly negative effect after 6 to 7 years, however, without becoming significant before the end of the simulation period.

Variance decomposition analysis

We also examine the forecasting error variance decomposition to determine the proportion of the movements in the time series that are due to shocks in their own series as opposed to shocks in other variables. Tables IV and

[9] Additionally the inflexible structure of government expenditures implies relative exogeneity in comparison with variables further down the Cholesky ordering.

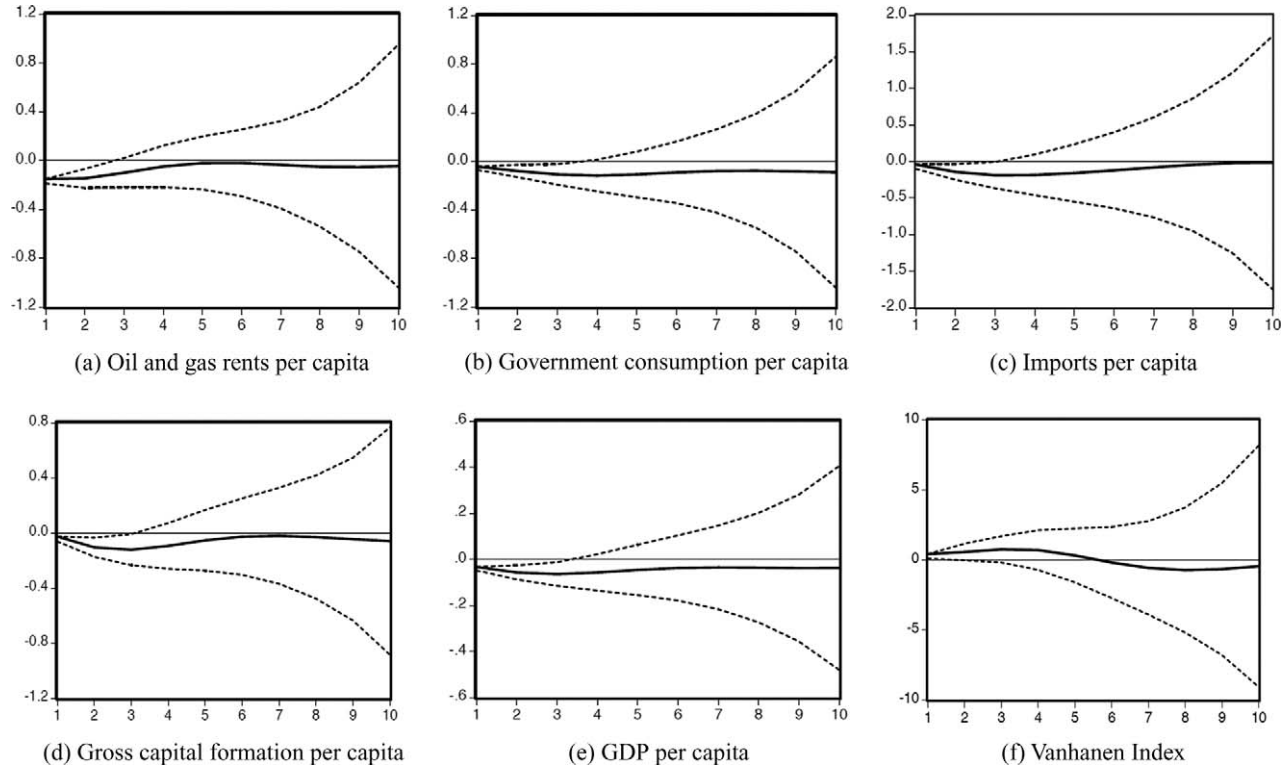

Figure 5. VAR responses to a shock in real oil and gas rents per capita (model with Vanhanen)
All variables (except Vanhanen index) are in logarithmic form and real terms.

V show that, for almost all variables, the largest portion of variation is explained by their own trend in the first year. Hence at the start of the simulations the historical trend of each variable explains a large part of its own variation. The only exception is GDP per capita, as about half its variations in the first year are explained by oil and gas rents per capita, reflecting high dependency of GDP per capita on oil and gas rents in Iran. Again the time path for this dependency (that reflects the adjustment potential of the economy) is illustrated as the maximum is reached in the second year and then reduces and ultimately decreases to a level that is lower than the initial level.

The variance decomposition analysis finds that for most of the variables the biggest portion of variations in the long run (after ten years) is explained by the variations in oil and gas rents. Only for *Polity* we find that the import channel is dominant, illustrating the importance of foreign trade as a determinant of changes in the political behaviour, but note that the shocks to the oil and gas rents variable is still very important in explaining the variations in polity as it explains 17% of variations in *Polity* after ten years.

These findings again underline the important role of oil and gas rents in explaining the variations in Iranian macroeconomic variables. In combination these findings suggest that sanctions that bite into the oil and gas rents can affect the Iranian key macroeconomic variables directly, but the impact on its regime is more indirect, especially for Iran's polity.

Robustness

In this section we present additional evidence as to the sensitivity of our key findings regarding the time profile of the economic and political impact of economic sanctions against Iran. The previous sections already provided some insight into the robustness of these findings since the results do not depend on the type of political variable (*Polity* or *Vanhanen*) and also because the set of 20 small VAR models finds a consistent pattern. In this section we consider some other potential weaknesses of our approach. Table VI summarizes alternative specifications and methodologies. We arrive at these results following the procedures that we used for the comprehensive VARs reported in the previous section. By way of reference, lines 1 and 2 report the findings for the comprehensive VAR models discussed earlier.

Generalized impulse responses. Lines 3, 4, 7, 8, 11 and 12 of Table VI report the Generalized Impulse Responses

Table IV. Variance decomposition VAR with Vanhanen index

Year	*Oil and gas rents*	*Government consumption*	*Imports*	*Gross capital formation*	*GDP*	*Vanhanen*
	Oil and gas rents					
1	100.0	0.0	0.0	0.0	0.0	0.0
2	98.1	0.8	0.1	0.0	0.0	0.9
5	85.8	1.9	0.9	5.2	2.2	4.0
10	75.9	2.1	4.9	5.0	2.1	10.0
	Government consumption					
1	29.3	70.7	0.0	0.0	0.0	0.0
2	43.6	42.7	3.1	0.9	6.7	3.0
5	67.0	21.4	3.5	1.9	2.5	3.7
10	68.7	12.6	2.8	2.2	6.8	6.9
	Imports					
1	6.5	27.1	66.4	0.0	0.0	0.0
2	24.7	15.7	46.0	0.3	0.1	13.2
5	44.0	11.2	23.3	0.2	0.6	20.6
10	46.7	10.3	21.3	0.7	2.4	18.5
	Gross capital formation					
1	6.3	8.5	19.1	66.1	0.0	0.0
2	29.8	13.9	24.9	28.1	0.2	3.2
5	43.1	10.8	17.1	13.7	5.9	9.4
10	32.3	9.5	14.0	11.9	23.6	8.8
	GDP					
1	46.2	4.2	2.0	19.8	27.9	0.0
2	59.0	4.4	3.8	15.3	13.7	3.8
5	58.7	2.8	3.5	6.2	19.3	9.4
10	42.2	4.0	2.6	9.2	30.3	11.6
	Vanhanen					
1	16.7	0.2	2.4	0.1	14.1	66.6
2	22.0	1.8	9.9	0.4	18.8	47.1
5	33.4	4.5	13.2	1.8	18.7	28.3
10	36.7	3.6	15.9	4.9	11.7	27.2

All variables except Vanhanen expressed as logarithm of real per capita value.

(GIR) developed by Pesaran and Shin (1998) in order to avoid the difficulties of identifying orthogonal shocks in VAR models. The GIRs construct an orthogonal set of innovations that does not depend on the VAR ordering. The responses are similar to those that we obtained earlier.

Macro aggregates. Lines 5–8 of Table VI report IRFs and GIRs for an alternative specification that uses the macro aggregate rather than its per capita expression. Lines 5–6 report the results for the two comprehensive VAR models (note that the GIRs in lines 7–8 are comparable to lines 3–4). The results of the macro aggregate and per capita specifications by and large agree.

Defense expenditures. In the past decade, the Iranian government has allocated a significant budget share to the military and security forces, especially since the end of the war with Iraq. This share was 16% in 1993 and reached 52% in 2006 (CBI, 2012). Indeed, Iran has moved towards militarization and strengthened military linkages with the national economy. The USA and EU sanctions against the Iranian energy industry aim to affect Iranian military ambitions and its financial sources (Farzanegan, 2012). Therefore in lines 9–12 we use defence expenditures instead of government consumption expenditures.[10] Typically, sanctions reduce defence expenditures, but this effect is not significant. While the patterns for *Polity* and *Vanhanen* are similar to the earlier estimated models, the short-run impact of sanctions on *Polity* is no longer significant – although *Polity* is marginally significant in the first year. This result does not depend on the ordering as it is also supported by the GIR in line 11.

The conclusion of Table VI is clear. The results survive our sensitivity analyses: the significant positive

[10] The correlation coefficient between defence expenditures and government consumption is 0.93.

Table V. Variance decomposition VAR with Polity

Year	*Oil and gas rents*	*Government consumption*	*Imports*	*Gross capital formation*	*GDP*	*Polity*
	Oil and gas rents					
1	100.0	0.0	0.0	0.0	0.0	0.0
2	97.3	0.0	0.0	2.1	0.4	0.2
5	89.4	0.0	0.4	8.2	1.6	0.3
10	87.1	0.1	0.5	9.2	2.1	1.1
	Government consumption					
1	17.4	82.6	0.0	0.0	0.0	0.0
2	28.5	68.2	0.4	1.0	1.1	0.9
5	44.3	40.2	0.4	5.8	7.2	2.2
10	53.4	22.7	0.3	6.3	15.9	1.4
	Imports					
1	12.7	11.5	75.9	0.0	0.0	0.0
2	17.6	11.8	67.9	1.2	0.6	0.9
5	27.0	12.0	47.1	6.8	4.7	2.4
10	36.3	9.6	33.5	7.9	10.9	1.8
	Gross capital formation					
1	17.7	2.5	30.0	49.8	0.0	0.0
2	25.8	2.2	29.8	36.6	2.1	3.5
5	35.4	1.5	19.3	20.2	14.0	9.5
10	39.3	1.8	12.6	13.4	25.9	7.0
	GDP					
1	54.2	3.3	5.7	14.2	22.6	0.0
2	56.9	1.8	5.6	8.5	26.2	0.9
5	55.6	1.0	3.4	3.2	34.8	2.1
10	49.0	4.9	2.0	2.2	40.5	1.3
	Polity					
1	12.2	0.8	2.4	0.0	7.9	76.7
2	15.6	0.5	9.3	0.0	8.7	65.9
5	18.1	0.4	21.3	1.1	9.4	49.8
10	16.6	1.0	21.8	4.4	11.6	44.7

All variables except Polity expressed as logarithm of real per capita value.

Table VI. Robustness checks

	Method	*Specification*	*Impact on*	*Short run*	*Medium*	*Long run*
1	IRF	Per capita	Polity	**Positive**	Positive	Negative
2	IRF	Per capita	Vanhanen	**Positive**	Positive	Negative
3	GIR	Per capita	Polity	**Positive**	Positive	Negative
4	GIR	Per capita	Vanhanen	**Positive**	Positive	Negative
5	IRF	Macro aggregates	Polity	**Positive**	Positive	Negative
6	IRF	Macro aggregates	Vanhanen	**Positive**	Positive	Negative
7	GIR	Macro aggregates	Polity	**Positive**	Positive	Negative
8	GIR	Macro aggregates	Vanhanen	**Positive**	Positive	Nil
9	IRF	Per capita, defense expenditures	Polity	Positive	Positive	Negative
10	IRF	Per capita, defense expenditures	Vanhanen	**Positive**	Positive	Negative
11	GIR	Per capita, defense expenditures	Polity	Positive	Positive	Negative
12	GIR	Per capita, defense expenditures	Vanhanen	**Positive**	Positive	Negative

Significant deviations in **bold**. Short run $\leq$ 2 years; medium 3–5 years; long run 6–10 years.

impact of sanctions that can be expected in the short term wanes due to economic adjustment.

Concluding remarks

We have focused on the purely economic costs of the oil boycott and have not studied the broader costs for society. Research has shown that substantial costs can be expected during sanction episodes in terms of health (Garfield, Devin & Fausey, 1995), gender (Drury & Peksen, 2012) and human rights (Browne, 2011). The occurrence of these side-effects is relevant but reflects a more general phenomenon than is suggested by research in the context of economic sanctions. Reductions in economic growth in general are associated with worse performance on human development indicators such as life expectancy, child mortality, primary completion rates and female enrolment rates. Analyzing this general pattern for 163 countries over the period 1980–2008, the World Bank (2010) finds that contractions of economic activity have been associated with deteriorating social indicators. In line with the World Bank findings, our economic findings appear also to have implications for the social impact of sanctions. Two findings are especially important for the discussion on sanctions. The World Bank finds that (i) the impact of declines in economic activity are of a long-run nature and (ii) the impact on human development of, on the one hand, growth and, on the other hand, decline is not symmetrical (decline has a much stronger impact). This implies, firstly, that the social impact of economic sanctions may well extend beyond the sanction episode and, secondly, that the deterioration during the initial phase will exceed the improvement during the recovery (that sets in either in the second phase or if the sanction is terminated). The latter is in line with our dynamic analysis that showed that the costs of imposing sanctions exceed the benefits of lifting sanctions.

The economic impact of an oil boycott on the Iranian economy is considerable: oil and gas rents are important drivers of the Iranian key macroeconomic variables and ultimately of its political system. A reduction of these oil and gas rents creates economic costs that act as incentives to move toward a more democratic setting. This effect, however, is only significant in the first two years and turns negative after six to seven years, reflecting that even high short-term sanction costs will wane due to economic adjustment. The policy implication of this result is clear: increasing global pressure via the Iranian energy industry, which is the core element of very recent sanctions, will initially cause effective damage to the Iranian economy, possibly pushing for more democracy or less autocracy and a softening of the Iranian negotiation position. In the long run the sanctions, however, are likely to have the opposite effect.

These findings are relevant for the policy debate on economic sanctions against Iran that all too often assume that 'protracted duration' is a key prerequisite for success (Maloney, 2009: 132) or that sanctions will not persuade 'Iran to return to the negotiation table' (Esfandiary & Fitzpatrick, 2011: 147). Our results, in contrast with these hypothesized impacts of sanctions, indicate that both key economic variables and the political system are not immune to economic coercion by other states. This impact is limited in time and occurs only in the first phase of the sanction episode. After the initial phase, adjustment of economic structures mitigates the economic and political impact of the sanctions. Sanctions may work in the short term; their impact in the long run is limited at best.

Replication data

The dataset, codebook and do-files for the empirical analysis in this article, as well as an appendix, can be found at http://www.prio.no/jpr/datasets. Estimations were done in Eviews5.

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