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# Identifying the Effects of Sanctions on the Iranian Economy using Newspaper Coverage*

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July 27, 2021

**Abstract**

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# 1 Introduction

Over the past forty years Iran has been subject to varying degrees of economic and financial sanctions, and asset freezes, which began in November 1979 when the U.S. placed an embargo on Iranian oil trade and froze $12 billion of Iranian assets held outside Iran with the aim of securing the release of U.S. hostages. Although this particular sanction episode was successfully negotiated in January 1981, U.S. policy towards Iran became increasingly entrenched, aimed at curtailing the economic and political influence of Iran in the Middle East region and beyond; a process which escalated over Iran's nuclear program. As a result, the Iranian economy has been operating for a prolonged period under severe and often quite harsh international restrictions, perhaps unique for a sizeable economy with deep historical roots in the global economy. Given the uncertainty and durability of sanction regimes, it is also important to bear in mind that, besides the direct effects of sanctions (arising from loss of oil export revenues, loss of access to currency reserves and other trade-related losses), sanctions also result in important and lasting indirect effects, such as rent-seeking, resource allocation distortions, and general costs associated with efforts involved in mitigating and circumventing the sanctions regimes. These indirect effects are likely to be more serious the longer the sanctions are in place, particularly when the prospect of a sanctions free outcome seems very remote.

The focus of the present paper is on the identification and quantitative evaluation of the direct and indirect effects of sanctions on the Iranian economy over the period 1989–2020, since the end of the Iran-Iraq War and the start of the reconstruction period under President Rafsanjani. We exclude the period 1979–1988 due to the special circumstances of the 1979 Revolution, the hostage crises and the ensuing eight year war with Iraq, which ended in August 1988. We also do not address the wider issue of the effectiveness of sanctions in achieving the foreign policy goals of the U.S. and its Western allies. Nor do we discuss Iran's ability to respond to sanctions in the rapidly changing geographical conditions of the region.

We try to capture the intensity of the sanctions and the international political pressure on Iran to comply by constructing a time series index based on daily newspaper coverage of the sanctions, their imposition, the intensity of their use, as well as their occasional removal. The idea of a newspaper coverage index was developed by Baker et al. (2016) for measurement of economic uncertainty, but to our knowledge it has not been utilized in the analysis of sanctions. As we shall see, the evolution of our proposed sanctions intensity index closely tracks the main sanctions time points, such as the U.S. Iran and Libya Sanctions Act of 1996, the U.S. export ban in 1997, the U.S. investment bans and asset freezes in 2006 and 2007 ("Iran Freedom and Support Act", and Executive Order 13438), the United Nations nuclear Resolutions (1737, 1747) during 2006 and 2007, the U.S. Comprehensive Iran Sanctions, Accountability, and Divestment Act of 2010, the U.S. National Defence Authorization Act of 2012, the partial lifting of U.N. sanctions under the Joint Comprehensive Plan of Action (JCPOA) in 2015 and its subsequent implementation in January 2016, and finally President Trump's unilateral withdrawal from the JCPOA agreement in 2018. See Figure 2. The sanctions intensity measure also correlates with the U.S. Treasury "Specially Designated Nationals And Blocked Persons List" (SDN) for Iran which has been publicly available since 2006.

We use the sanctions intensity variable in reduced form equations as well as in structural vector autoregressive (SVAR) models to identify short run and long run effects of sanctions (direct and indirect effects) on Iran's rial/USD exchange rate, money supply growth, inflation and output growth, whilst controlling for oil price changes, foreign output growth, and other global factors such as equity market volatility. By making use of the sanctions intensity index we also avoid some of the limitations of comparative approaches used in the literature for policy evaluations, such as the synthetic control method (SCM) proposed by Abadie and Gardeazabal (2003), and the panel data approach proposed by Hsiao et al. (2012). These techniques require pre-policy intervention outcomes to estimate weighted averages of post policy outcomes for a "pre-selected" control group to be used as the basis of comparisons. In the case of Iran there are no clear cut "sanctions on" and "sanctions off" periods, and it is unclear which countries should be included in the control group given the continued importance of the Iranian economy in the region.

The main drawback of our approach is its inability to distinguish between the direct and indirect effects of sanctions, since we have not been able to come up with satisfactory measures to control for rent-seeking, and other economic distortions that might have been caused by the sanctions. There is no doubt that the Iranian economy would have been subject to distortions and economic mismanagement even in the absence of any sanctions, and it would seem unlikely to be able to separate sanctions-induced distortions from all other distortions either. For these reasons, our results should be approached with caution. What we estimate can be viewed as measuring the combined effects of sanctions and sanctions-induced distortions, broadly defined. Seen from this perspective, we find that the sanctions intensity variable has highly statistically significant effects on exchange rates, inflation and output growth, but not on money supply growth. These estimates proved to be robust to alternative specifications and after allowing for a host of control variables.

Our results also show that strong currency depreciations (with substantial overshooting), and high inflation rates are important channels through which sanctions affect the real economy. On the other hand, the overexpansion of the money supply used to compensate underdeveloped capital and money markets does not seem to affect the path of other domestic variables, once we control for inflation and variations in exchange rates.

Using impulse response analysis and forecast error variance decomposition techniques, we also find a significant over-reaction of the rial to sanctions, with a subsequent rise in inflation and a fall in output shortly after. The economy adapts reasonably quickly to sanction shocks, a property that has already been documented by Esfahani et al. (2013), who consider the effects of oil revenue shocks on output growth and inflation. The forecast error variance decompositions also show that, despite the inclusion of the sanctions intensity variable in the VAR, around 80 per cent of variations in foreign exchange and 83 per cent of variations in output growth remain unexplained, and most likely relate to many other latent factors that drive the Iranian economy. We also estimate that in the absence of sanctions Iran's output growth could have been around $4 - 5$ per cent, as compared to the 3 per cent realized.

We are also able to identify negative effects of sanctions on the labor market. The employment rate with respect to other countries in the Middle East and North Africa (*MENA*) region has systematically decreased after sanctions were imposed, and women seem to have paid the higher price, with significant declines in female labor force participation. From a socio-demographic standpoint, we also find that sanctions have negatively affected secondary school education, with the number of schools and teachers both sharply down in response to new sanctions waves. Again, gender effects seem to be at play here. We find changes in sanctions intensity to have statistically significant negative effects on the ratio of female to male students. These outcomes could be due to government responses to sanctions-induced reductions in oil income, with associated budgetary allocation away from education and female participation.

Sanctions have also had a number of positive unintended consequences. Interestingly, the Iranian economy at the onset of sanctions was as heavily dependent on oil exports as countries such as Saudi Arabia. Restricting oil exports over a relatively long time period has led to important structural transformations of the Iranian economy, with significant increases in non-oil exports, most notably petrochemicals, light manufacturing products and agricultural goods. There have also been significant successes in internet access and the associated rise of high-tech and knowledge-based companies in Iran, such as Digikala, Snapp, and Cafe Bazaar, to name just a few. It is likely that U.S. sanctions have been partly responsible for the rapid rise of high-tech companies in Iran over the past decade.

Our research does not encompass health outcomes because of the lack of sufficiently long time series on the healthcare system. A number of recent on-field reports suggest that medicines (especially quality drugs) were increasingly harder to find in Iran even before the Covid-19 pandemic.[1]

Overall, there seems little doubt that sanctions have harmed the Iranian economy and weakened its socio-economic infrastructure. But removal of sanctions on their own is unlikely to ensure a period of sustained growth and low and stable inflation, and many policy reforms are needed to address sanctions-induced price distortions as well as other distortions due to general economic mismanagement, poor governance, and the ambiguities that surround the relative roles of semi-government agencies and the private sector in the economy. Subsidies on essential food items and energy (fuel as well as electricity) have created inefficiencies, smuggling, and damaging unintended consequences. Subsidies on electricity, for example, have led to excessive ground water withdrawals from electricity-powered irrigation wells, and more recently for mining crypto-currencies, one of the sources of Iran's worsening water shortages, and frequent electricity blackouts.

**Related literature**

As noted already, in this paper we are primarily interested in the economic implications of sanctions with a focus on the case of Iran, which is arguably the most sanctioned country in the world. Yet

[1] To our knowledge there are no U.S. sanctions on the export of essential drugs to Iran. But large pharmaceutical and medical companies tend to avoid transactions with Iran because of the highly complex financial regulatory structure which is in place as a part of U.S. sanctions. Different laws overlap making some transactions appear legal on the assistance side but potentially illegal from a financial perspective (Peksen (2009), Kokabisaghi (2018)).

there exists limited systematic knowledge of the effects of a prolonged period of sanctions on a major economy such as Iran (Greenwald, 2020). We do not address the wider issues discussed in the literature about the efficacy of sanctions as a foreign policy tool, although it is hoped that the economic analysis provided in this paper could help in this regard. [2] Studies that are more directly related to our paper either consider a specific sub-period or use shocks to oil export revenues as representing a sanction shock. Gharehgozli (2017) considers the effects of sanctions just before JCPOA, which we discuss in further detail in Section 3 below. Dizaji and van Bergeijk (2013) study the impact of economic sanctions via changes in oil revenues using a VAR model. They show that sanctions are effective in the short-run but their relevance fades with time. Similar results are reported by Esfahani et al. (2013), who find that shocks to foreign output and oil exports are rather short-lived for Iran. This is an important feature of the Iranian economy which is also confirmed by our analysis using the new sanctions intensity variable. Haidar (2017) uses micro-data over the period 2006–2011 to find that two-thirds of Iran's sanctioned non-oil exports were redirected to other non-sanctioning countries. It is also found that large exporters appear to suffer less from export sanctions. Popova and Rasoulinezhad (2016) find a similar geographical redirection of Iran's non-oil exports over the period 2006–2013 of trading partners away from Western economies to countries in the region (notably Iraq), China and other Asian economies. Farzanegan and Hayo (2019) analyze the effect of sanctions to expand the shadow economy. Although not strictly quantitative in nature, a number of studies maintained that the burden of economic sanctions for Iranian growth was high but not decisive to bring about political change in Iran. (Carswell (1981), Amuzegar (1997a), Amuzegar (1997b), Dadkhah and Zangeneh (1998), Downs and Maloney (2011) and Borszik (2016)).

Sanctions have also played an important role in shaping Iran's monetary and financial system. Mazarei (2019) analyzes the current state of the Iranian financial system and its fragility. Farzanegan and Markwardt (2009) focus on the extent to which Iran suffers from a form of "Dutch disease", thus advocating for a sovereign oil fund to mitigate inflationary pressures and risks of currency crises.

[2] The effectiveness of sanctions in achieving foreign policy goals has been studied extensively in the literature. Hufbauer et al. (1990) examine 116 case studies covering the period from the economic blockade of Germany during World War I through the U.N.-U.S. embargo of Iraq in 1990. Further overviews are provided in Morgan et al. (2014).and Doxey (1996). Critical assessments of sanctions as a policy tool are provided by Weiss et al. (1997), Pape (1997, 1998), Andreas (2005), and Peksen and Drury (2010). These studies highlight possible counterproductive effects of economic sanctions. Naghavi and Pignataro (2015) provide a game-theoretic analysis of sanctions and its application to Iran.

Mazarei (2020) highlights the danger of inflation for Iran in the wake of sanctions and the pandemic. There are also several studies on the determinants of inflation in Iran (not related to sanctions), which could be of interest. See, for example, the studies by Liu and Adedeji (2000), Celasun and Goswami (2002), and Bonato (2008).

Sanctions have often led to the establishment of multiple exchange rate markets with important rent-seeking opportunities and related economic distortions. Currently, there are three different exchange rates for the rial.[3] Bahmani-Oskooee (1996) provides an earlier account of the gains obtainable in Iran from the black market premium, and the need to consider the free market rate rather than the official one when the Iranian money demand is to be assessed; we follow this approach when conducting our analyses and disregard the official rate. The economic implications of multiple exchange rates in Iran are discussed in Pesaran (1992), Farzanegan (2013) and Majidpour (2013).

The role of gender inequality in Iran as compared to other Middle Eastern countries both in terms of labor force participation and education has also been studied by Esfahani and Shajari (2012) and Majbouri (2015), among others, and Alizadeh (2017) provides a review.[4]

The rest of the paper is organized as follows. Section 2 offers an overview of the Iranian economy under sanctions. Section 3 discusses alternative approaches to the analysis of policy interventions, and develops a structural vector autoregressive framework with latent factors used to identify the effects of sanctions on the Iranian economy. Dynamics of sanctions and the channels through which sanctions affect the Iranian economy are discussed in Section 4. Section 5 explains how we construct the sanctions intensity index from six leading newspapers, and its co-movements with historical events. Section 6 presents the estimates of the structural model and reports the related impulse responses and forecast error variance decompositions of sanction and domestic shocks, as well as providing an estimate of sanctions-induced output losses. Additional economic and socio-demographic results are obtained from the reduced form analyses in Section 7. Section 8 ends with some concluding remarks. An online supplement provides details on the construction of our sanctions intensity variable, all data sources,

[3] The three exchange rates are: (*i*) The official exchange rate to import essential items such as medicine, grain and sugar; (*ii*) The *Nima rate*, officially set at 2 per cent above the official rate by Bank Markazi daily, but in practice it is subject to much higher premiums and is reserved for non-oil exporters; (*iii*) The free market rate used for all other transactions.

[4] We do not address the effects of economic sanctions on government and military expenditures. Interested readers may wish to consult the papers by Dizaji (2014), Dizaji et al. (2014), Farzanegan (2011), Farzanegan (2019), Dizaji and Farzanegan (2021), Farzanegan (2014) and Farzanegan and Alaedini (2016).

further methodological notes and empirical analyses, and a comprehensive list of sanctions imposed against Iran over the past forty years.

## 2 Sanctions and the Iranian economy: an overview

The evolution of the Iranian economy over the past forty years has been largely shaped by the Revolution and the eight-years war with Iraq (1979-1988), prolonged episodes of economic and financial sanctions, and often very different policy responses to sanctions and economic management under the four presidents that have held office since 1989. Initially, U.S. sanctions were much more clearly targeted. The goal of the 1980–81 sanctions was to negotiate the release of U.S. hostages, and the 1987 sanctions to end hostilities in the Persian Gulf and bring about an end to the war with Iraq. These sanctions aimed at limiting Iran's access to foreign exchange earnings through asset freezes and, more importantly, by reducing Iran's capacity and ability to produce and export oil.[5]

The evolution of Iran's oil exports since the Revolution is shown in *Panel A* of Figure 1. Iran's oil exports had been already cut by half from the pre-Revolution peak of 6 millions barrels per day (mb/d). The first U.S. sanctions drove Iran's oil exports to the low of 700,000 b/d before recovering somewhat after the sanctions were lifted in January 1981. However, since the lifting of the sanctions coincided with the intensification of the war with Iraq, oil exports did not recover fully till after the war ended in 1988. From 1989 to 2005 with improvements in the diplomatic relationships between Iran and the U.S. and other Western countries, oil exports started to rise and stabilized to around 2.5 mb/d under the presidencies of Rafsanjani (1989q3–1997q2) and Khatami (1997q3–2005q2). Oil exports began to decline again from 2007 after the imposition of U.S. and U.N. sanctions in December 2006 aimed at halting Iran's uranium enrichment program which had gathered pace under the newly elected President Ahmadinejad. Initially, the sanctions targeted investments in oil, gas and petrochemicals, and exports of refined products, but then were later expanded to include banking, insurance and shipping. Sanctions also targeted the Islamic Revolutionary Guard Corps (IRGC) and its vast commercial and industrial empire whose activities had been expanded under President Ahmadinejad's administration (2005q3–2013q2). Sanctions against Iran were intensified further under President Obama and their coverage expanded to

[5] For an overview of U.S. sanctions against Iran see also Chapter 9 of Maloney (2015).

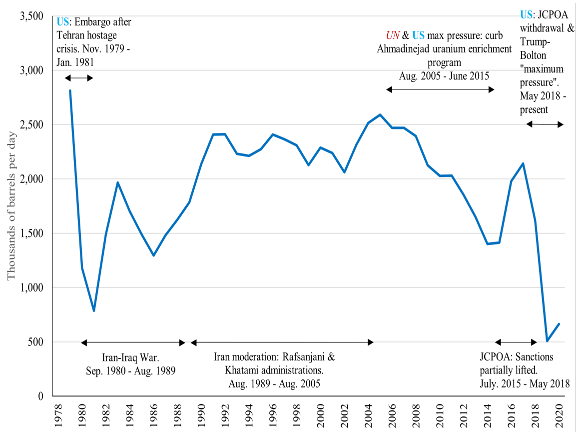
imports of rugs, pistachios, and caviar, representing some of Iran's major non-oil exports. Additional financial sanctions were imposed on Iran from July 2013, almost immediately before President Rouhani (2013q3–2021q2) took office. The coverage of U.N. and U.S. sanctions increased well beyond the oil and gas sectors and affected all aspects of Iranian foreign trade and international finance, and even the international payment system of Bank Markazi (Iran's Central Bank). The extensive coverage of the sanctions, their multilateral nature, coupled with the start of Rouhani's administration in 2013 paved the way for the 2015 nuclear agreement, Joint Comprehensive Plan of Action (*JCPOA*), implemented in January 2016 which led to the easing of some of the U.S. sanctions and the lifting of U.N. and European Union sanctions against Iran. But the benefits of the JCPOA to Iran were limited, as many non-US global companies and banks were hesitant to deal with Iran because of the remaining U.S. sanctions, as well as concerns over money laundering, opacity of ownership, and the fragility of the Iranian banking system. As it turned out, JCPOA was also short lived, with oil exports sharply declining after May 2018, when U.S. President Trump unilaterally withdrew from JCPOA, and adopted the policy of "maximum pressure" against Iran. With the election of President Biden in November 2020, there are negotiations for the U.S. to return to the 2015 nuclear agreement, although our analysis will be pre-dating these negotiations.

The U.S. sanctions against Iran were mainly of extra-territorial nature. Iran-U.S. trade had already been cut drastically after the Revolution and did not recover after the resolution of the hostage crisis. In response to sanctions, the Iranian government made concerted efforts to re-direct Iran's foreign trade from the West to the East (primarily China) and to neighboring countries, focussing on trading companies that operate outside the reach of the U.S. Treasury. The sources of foreign exchange were also diversified from oil to non-oil exports of goods and services. In this regard, ironically, Iraq became one of the most important importers of Iranian products and services (electricity, agricultural products and light manufacturing) after the fall of Saddam in 2003. Turkey and Qatar have also played important roles in facilitating Iran's foreign trade and international payments. *Panel B* of Figure 1 shows that the share of oil and gas exports declined steadily from 96 per cent of total exports in 1979 to around 60 per cent in 2018, before the full impact of the U.S. withdrawal from Iran's oil exports. Over the same period non-oil exports have increased from 753 million dollars to 37 billion dollars.

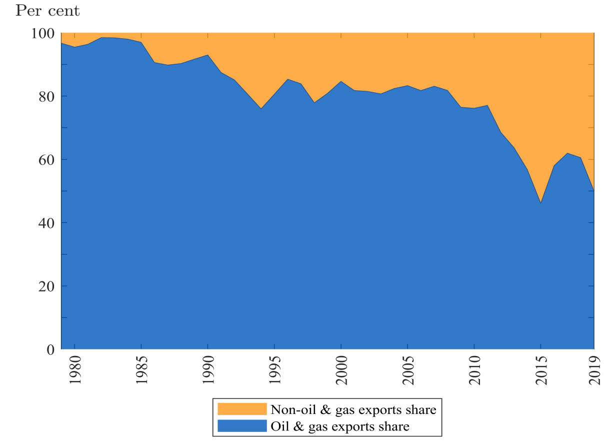
Nevertheless, the Iranian financial system has found it difficult to adapt to the new sanctions suffi-

Figure 1: Relevant Iran's and World macroeconomic and financial time series over the period 1979–2020

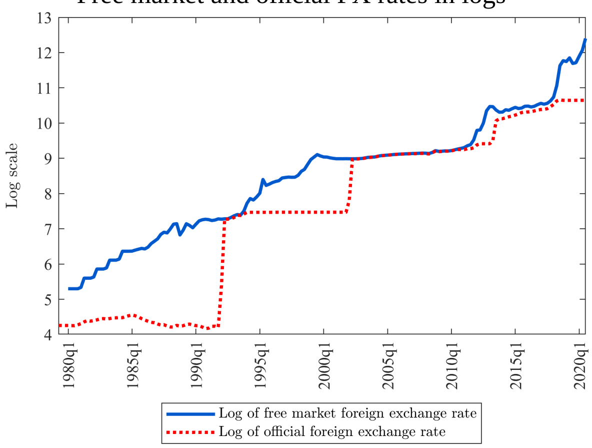
*Panel A*
Iranian oil exports[1]



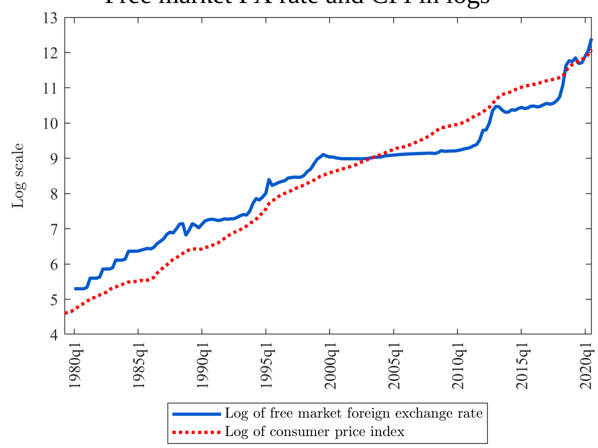

*Panel B*
Shares of oil and gas vs. non-oil and gas exports revenues[2]



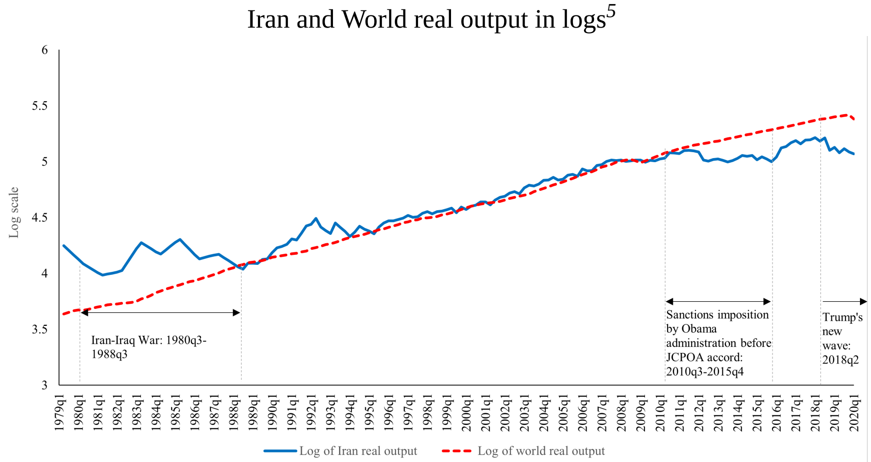

*Panel C*
Free market and official FX rates in logs[3]




*Panel D*
Free market FX rate and CPI in logs[4]




*Panel E*
Iran and World real output in logs[5]




**Notes**: *1.* Annual data over the period 1979–2020. *2.* Annual data over the period 1979–2019. *3.* Quarterly data over the period 1979q2–2020q3. Foreign exchange rates are expressed as number of Iran's rials per U.S. dollars. *4.* Quarterly data over the period 1979q2–2020q3. CPI stands for Consumer Price Index, and it is equal to 100 in 1979q2. *5.* Quarterly data over the period 1979q2–2020q1. The world real output is a weighted average of the natural logarithm of real output for 33 major economies.
See Sections S.2.2 and S.2.3 in the data appendix of the online supplement for details on calendar conversions, and sources of the data.

Table 1: Free market and official foreign exchange rate depreciation, inflation, real output growth, and sanctions intensity over the period 1979q3–2021q1

*Per cent per annum*

| Periods | Free FX depreciation | Official FX depreciation | Inflation | Output growth | Sanctions intensity (0,1) | |
|---|---|---|---|---|---|---|
| | | | | | Mean | Median |
| Revolution and Iran-Iraq War[1] (1979q3–1989q2) | 19.94 | 0.28 | 18.29 | -1.60 | 0.20 | 0.11 |
| Rafsanjani presidency (1989q3–1997q2) | 16.55 | 39.83 | 21.17 | 5.16 | 0.11 | 0.10 |
| Khatami presidency (1997q3–2005q2) | 7.90 | 20.34 | 14.53 | 4.72 | 0.15 | 0.13 |
| Ahmadinejad presidency (2005q3–2013q2) | 17.08 | 5.16 | 18.15 | 1.68 | 0.38 | 0.39 |
| Rouhani presidency[2] (2013q3–2021q2) | 25.34 | 14.66 | 19.61 | 0.83 | 0.34 | 0.27 |
| *Post-revolution full sample*[2] (1979q3–2021q1) | 17.39 | 15.30 | 18.34 | 2.01 | 0.23 | 0.15 |
| *Post-War full sample*[2] (1989q1–2021q1) | 17.38 | 19.88 | 18.30 | 3.13 | 0.24 | 0.16 |

**Notes**: *1*. Data on free market foreign exchange rate start in 1980q2. *2*. Data on foreign exchange rates (free market and official rate), and inflation end in 2021q1, data on output growth end in 2020q1, data on sanctions intensity end in 2020q3. See Section 5 of the paper for the sanctions intensity variable definition over the range (0,1). See Sections S.2.1, S.2.2, and S.2.3 in the data appendix of the online supplement for details on the construction of the sanctions intensity variable, calendar conversions, and sources of the data used.

ciently quickly, resulting in large depreciations of the free market rate of the rial against the U.S. dollar, with the official rate lagging behind for a number of years, thus creating opportunities for rent-seeking and often corrupt business practices.[6] *Panel C* of Figure 1 shows the evolution of the free and official rates (in log scales), and clearly shows the episodic nature of the jumps in the free market rate, followed by the sluggish catch up of the official rate. Given the relevance of imports in the Iranian economy, and the role of the U.S. dollar as the store of value and as a hedge against inflation for many Iranians, the fall in value of the rial quite rapidly translates into higher consumer prices, with the rise in prices somewhat moderated due to government imports of food and medicine at official rates. But as the gap between the official and market rates closes over time, consumer prices end up reflecting the full extent of depreciation of the rial on the free market. The time profiles of free market rate and consumer prices (in log scales) are depicted in *Panel D* of Figure 1, and show the very close association that exists between the two series. As can be seen from Table 1, over the period 1989q1–2021q1 the free market rate has depreciated around 17.4 per cent per annum as compared to the average annual rate of inflation of

[6] The development of the free market exchange rate, also known as the ‘black’ market rate during the 1979-1988 period, is discussed in Pesaran (1992).

around 18.3 per cent over the same period, representing a gap of around 1 per cent between the two series. But according to the Purchasing Power Parity (PPP), the difference between inflation and exchange rate depreciation should match the average annual U.S. inflation, which is estimated to be around 2.5 per cent over the same period. [7] One reason for the discrepancy (of 1.5 per cent) could be due to the official rate being kept systematically below the free market rate, and the lower than expected long run inflation should be set against the cost of price distortion and corruption that multiple exchange rate regimes entail.

It is also important to note that not all foreign exchange crises can be traced to the intensification of sanctions. Iran has witnessed major currency crises during all the four presidencies since 1989, whilst only the last two currency crises can be directly attributed to intensification of the sanctions. The currency crises during Rafsanjani and Khatami presidencies have domestic roots resulting from the rapid expansion of imports and low oil prices, coupled with accommodating fiscal and monetary policies. [8] As shown in Table 1, the average rate of inflation has been systematically high across all the four presidencies, and does not seem to correlate with changes in sanctions intensity. Even under Khatami's Presidency the average annual inflation still amounted to 14.5 per cent, despite his conciliatory foreign policy and a much lower rate of currency depreciation (7.9 per cent as compared to 17.4 per cent over the full sample).

Turning to the effects of sanctions on real output, *Panel E* of Figure 1 shows the time profile of Iran's real Gross Domestic Product (GDP) and world GDP in log scales. World output is computed as a weighted average of some of the largest 33 economies with details provided in the online supplement. Iran's average output growth rates over various sub-periods starting with the period of the Revolution and the Iran-Iraq War, and followed by the four presidencies since 1989 are also summarized in Table 1. After the 1.6 per cent contraction during 1979q3–1989q2, Iran's economy recovered strongly during President Rafsanjani's administration and grew by an average of 5.2 per cent per annum, an upward

[7] The PPP is a long-run relationship that relates the exchange rate between two currencies to their relative price of goods: $P_t = E_t P_t^*$, with $E_t$ being the exchange rate representing the number of domestic currency units that can be bought with one unit of foreign currency, $P_t$ and $P_t^*$ denote the domestic and foreign price levels.

[8] During the reconstruction period under President Rafsanjani imports of goods and services doubled over the period 1989–1991 (rising from 13.5 to 25 billion dollars, and Iran's foreign debt rose to 23.2 billion dollars by the end of 1993. For further details of the developments that led to the currency crisis under President Rafsanjani, see Section 3 of Pesaran (2000).

trend which continued over the period of Khatami's presidency. [9] Iran's output growth was also in line with the growth of world output during the 1989–2005 period. This period also coincided with the lowest levels of sanctions intensity that Iran experienced over the past forty years, and is in stark contrast with the growth performance under Ahmadinejad and Rouhani presidencies that coincided with new U.S. and U.N. sanctions during the period before JCPOA in 2015, and the subsequent "maximum pressure" strategy initiated by Trump in 2018. The results in Table 1 clearly provide a *prima facie* case for sanctions having important adverse effects on Iran's output growth. It is also worth noting that Turkey, a country often compared to Iran being of a similar size and in a similar region, grew by an average annual rate of 4 per cent over the 2005–2020 period as compared to Iran's 1.3 per cent average growth rate over the same period.

Comparing Iran's output growth with that of world output growth over the 1989–2019 period also suggests an output growth shortfall of around 1 per cent per annum, which could be contributed to the sanctions, although such a comparison does not take account of Iran's potential as an emerging economy. Even if we exclude the war periods, we also observe a much larger output growth volatility in Iran as compared to the volatility of world output growth volatility or a number of emerging economies of similar size to Iran, such as Turkey or Saudi Arabia. Iran's output growth volatility (as measured by standard deviations of output growth) was almost five times as large as the global output growth volatility (12.61 versus 2.69 per cent). [10] Comparing Iran and Turkey over the same period we also find that Turkey grew at an average annual rate of 4 per cent with volatility of 10.8 per cent, a country also known for high inflation and repeated currency crises. [11] Finally, sanctions have most likely also contributed to the de-coupling of the Iranian economy from the rest of the world. Again comparing Iran and Turkey, we note that the correlation of Iran's output growth with the world output growth is around 0.12, barely statistically significant, as compared with a correlation of 0.33 for Turkey.

There seems little doubt that sanctions have adversely affected the Iranian economy, contributing to

[9] Detailed analyses of reconstruction of the Iranian economy under President Rafsanjani are provided in Karshenas and Pesaran (1995) and Chapter 5 of Maloney (2015).

[10] Mohaddes and Pesaran (2013) document the high volatility of Iran's oil export revenues as one of the factors behind Iran's low growth and high volatility. A large part of the volatility of Iran's oil export revenues is traced to high volatility of barrels of oil exported, largely due to vagaries of sanctions. By comparison the volatility of oil prices is of secondary importance. This contrasts to the volatility of Saudi Arabia oil revenues which is largely governed by changes in international oil prices.

[11] The average annual output growth of Saudi Arabia over the 2005-2019 period was also similar to Turkey and amounted to 4.3 per cent.

low growth, high inflation and increased volatility. What is less clear is how to carry out a quantitative evaluation and identification of channels through which sanctions have affected the Iranian economy over time, in particular the dynamics of responses and the time horizon over which the effects of sanctions filter out throughout the economy. To this end, a formal model is required where conditions under which the effects of sanctions can be identified are made explicit, and their dynamic implications are estimated and evaluated. It is to this task that we now turn in the rest of this paper.

## 3 Identification of sanctions effects: methodological issues

Identifying the effects of sanctions on the Iranian economy is challenging even if a reliable measure of sanctions intensity is available. As with all macro policy interventions, when identifying the effects of sanctions we also need to take account of confounding factors that are correlated with changes in sanctions intensity, and which at the same time have a causal influence on target variable(s) of interest such as output growth, inflation, health and education outcomes. In situations where a policy intervention has differential effects over time and across many different units such as households or firms, difference-in-difference techniques are used whereby changes in outcomes during policy on and policy off periods for those affected by the intervention are compared to corresponding changes in outcomes for a control group that is not directly affected by the intervention. This method is clearly not applicable to the analysis of policy interventions that target a particular entity such as a region or country, and a different approach is needed. Currently, there are two such approaches: the Synthetic Control Method (*SCM*) advanced by Abadie and Gardeazabal (2003) and the Panel Data Approach (*PDA*) proposed by Hsiao et al. (2012).[12] Both approaches compare outcomes for the country (region) subject to the intervention with a weighted average of outcomes from a control group. The former was originally applied to quantify the economic costs of political instability in the Basque Country in Spain, and the latter to evaluate the economic effects of the hand-over of Hong Kong to China in 1997. Both studies consider discrete policy interventions and do not allow for the policy intensity to vary over time. Perhaps most importantly they both use pre-policy outcomes to estimate the weights applied to the countries included in the control

[12] Further details and extensions of SCM are discussed in Abadie et al. (2010) and Doudchenko and Imbens (2016).

group. The main difference between the two approaches lies in way the weights are estimated.[13]

The application of these approaches to the case of Iran is complicated by the fact that imposition of sanctions coincided with the onset of the Revolution which renders the pre-sanctions period of limited relevance. Also, as noted earlier, the scope and intensity of sanctions against Iran have undergone considerable changes over the past forty years and there are no clear cut periods that one could identify as "sanctions on" periods to be compared to "sanctions off" periods, in which all sanctions were levied. There is also the additional challenge of identifying countries for inclusion in the control group.

To our knowledge, the only study that applies SCM to Iran is by Gharehgozli (2017), who considers the effects of the intensification of sanctions just before the JCPOA agreement in July 2015 on Iran's real GDP, treating the years 2011–2014 as the "sanctions on" period as compared to the preceding years 1995–2010 as the "sanctions off" period. She then selects 13 countries worldwide to mimic a "synthetic" Iran as a weighted average of GDP of these economies with their respective weights determined using the SCM based on seven different macroeconomic indicators. She concludes that the 2011–2014 sanctions resulted in Iran's real GDP to fall by as much as 17 per cent, as compared to the synthetic sanctions free Iran, with all the output short fall attributed to sanctions.

We depart from the mainstream literature reviewed above and consider the following model for Iran quarterly output growth

$$\Delta y_t = \alpha + \lambda \Delta y_{t-1} + \psi_0 s_t + \psi_1 s_{t-1} + \beta' \mathbf{x}_t + \gamma' \mathbf{f}_t + u_t, \tag{1}$$

where $\Delta y_t$ is the output growth, $s_t$ measures the intensity of sanctions against Iran, $\mathbf{x}_t$ and $\mathbf{f}_t$ are respectively observed and unobserved control variables, and $u_t$ is an idiosyncratic error term, distributed independently of $(s_t, \mathbf{x}_t, \mathbf{f}_t)$. The measurement of the sanctions intensity variable, $s_t$, will be discussed in Section 5, and will be treated as given for now. It is assumed that part of the change in the intensity of sanctions affects Iran's output growth with a lag, thus distinguishing between short term, $\psi_0$, and long term, $\theta = (\psi_0 + \psi_1)/(1-\lambda)$, effects of sanctions.

Despite the introduction of $s_t$, identification of the sanctions coefficients, $\psi_0$ and $\psi_1$, depends on the confounding observed, $\mathbf{x}_t$, and unobserved, $\mathbf{f}_t$, factors. In the present reduced-form setting, for $\mathbf{x}_t$

[13] Gardeazabal and Vega-Bayo (2017) provide a comparative simulation analysis of SCM and PDA, with a follow up critique by Wan et al. (2018).

we consider changes in international oil prices. The effects of sanctions on output growth that operate through exchange rate, liquidity, and inflation will be addressed in Section 4. Here we are concerned with both direct and indirect effects of sanctions on output growth and for this reason we will not be including any of the domestic variables in $\mathbf{x}_t$. The main challenge is how to identify and estimate $\mathbf{f}_t$. In this regard our approach is closely related to the *PDA* (Hsiao et al. (2012)). To this end, we consider the following equations for output growth for the rest of the world

$$\Delta y_{it} = \alpha_{iy} + \beta'_{iy}\mathbf{x}_{it} + \gamma'_{iy}\mathbf{f}_t + u_{y,it},\ i = 1, 2, ..., n, \tag{2}$$

where $\Delta y_{it}$ denotes output growth in country $i$ (excluding Iran), $\mathbf{x}_{it}$ is a $k \times 1$ vector of control variables specific to country $i$, and $\mathbf{f}_t$ is the $m \times 1$ vector of unobserved common factors, and $u_{y,it}$ are idiosyncratic shocks to output growth that are serially uncorrelated but could be weakly cross correlated. [14] By allowing the factor loadings, $\gamma_i$, to differ across countries, we do not assume that all economies are equally affected by the same factors, an assumption that underlies the DiD approach. We also depart from SCM and PDA and, unlike these approaches, we do not require a "donor pool" of countries to be selected for comparative analysis. Instead, we assume that $\mathbf{x}_{it}$ also follows similar multi-factor structures, and impose a rank condition which allows us to identify $\mathbf{f}_t$ as weighted averages of $\Delta y_{it}$ and $\mathbf{x}_{it}$ over $i$ (excluding Iran). Any granular weights can be used to construct these averages, such as simple averages. But in cases where $n$ is not sufficiently large and there are dominant economies such as the U.S., it is advisable to use output shares as weights. Accordingly, suppose that

$$\mathbf{x}_{it} = \alpha_{ix} + \Gamma'_{ix}\mathbf{f}_t + \mathbf{u}_{x,it},\ i = 1, 2, ..., n, \tag{3}$$

where $\Gamma_{ix}$ is a $k \times m$ matrix of factor loadings, and $\mathbf{v}_{it}$ is a $k \times 1$ vector that follows general stationary processes that are weakly cross-sectionally correlated. Combining (2) and (3) we have

$$\begin{pmatrix} 1 & -\beta'_{iy} \\ \mathbf{0} & \mathbf{I}_k \end{pmatrix} \mathbf{z}_{it} = \begin{pmatrix} \alpha_{iy} \\ \alpha_{ix} \end{pmatrix} + \begin{pmatrix} \gamma'_{iy} \\ \Gamma'_{ix} \end{pmatrix} \mathbf{f}_t + \begin{pmatrix} u_{y,it} \\ \mathbf{u}_{x,it} \end{pmatrix},$$

[14] A set of random variables, $\{u_{it}, i = 1, 2, ..., n\}$ is said to be weakly cross correlated if $\sup_j \sum_{i=1}^n |Cov(u_{it}, u_{jt})| < C < \infty$. It then follows that $\sum_{i=1}^n w_i u_{it} = O_p(n^{-1/2})$, for any granular weights, $w_i$, such that $w_i = O(n^{-1})$ and $\sum_{i=1}^n w_i^2 = O(n^{-1})$. An obvious example is the simple weights $w_i = 1/n$. For further details see Chudik et al. (2011).

which yields $\mathbf{z}_{it} = \mathbf{c}_i + \mathbf{A}_i \mathbf{f}_t + \mathbf{B}_i \mathbf{u}_{it}$, where

$$\mathbf{c}_i = \begin{pmatrix} \alpha_{iy} + \beta_i' \\ \alpha_{ix} \end{pmatrix}, \mathbf{A}_i = \begin{pmatrix} \gamma_{iy}' + \beta_{iy}' \Gamma_{ix}' \\ \Gamma_{ix}' \end{pmatrix} \mathbf{f}_t, \text{ and } \mathbf{B}_i = \begin{pmatrix} 1 & \beta_{iy}' \\ \mathbf{0} & \mathbf{I}_k \end{pmatrix}.$$

Averaging $\mathbf{z}_{it}$ over $i$ using the weights $w_i$ we now have $\bar{\mathbf{z}}_{wt} = \bar{\mathbf{c}}_w + \bar{\mathbf{A}}_w \mathbf{f}_t + \sum_{i=1}^n w_i \mathbf{B}_i \mathbf{u}_{it}$,where $\bar{\mathbf{z}}_{wt} = \sum_{i=1}^n w_i \mathbf{z}_{it}$, $\bar{\mathbf{c}}_w = \sum_{i=1}^n w_i \mathbf{c}_i$, $\bar{\mathbf{A}}_w = \sum_{i=1}^n w_i \mathbf{A}_i$. Suppose now that the $(k+1) \times m$ matrix $\bar{\mathbf{A}}_w$ is full column rank (that requires $m \leq k+1$) then we can solve for $\mathbf{f}_t$ as[15]

$$\mathbf{f}_t = \left(\bar{\mathbf{A}}_w' \bar{\mathbf{A}}_w\right)^{-1} \bar{\mathbf{A}}_w' \bar{\mathbf{c}}_w + \left(\bar{\mathbf{A}}_w' \bar{\mathbf{A}}_w\right)^{-1} \bar{\mathbf{A}}_w' \bar{\mathbf{z}}_{wt} - \left(\bar{\mathbf{A}}_w' \bar{\mathbf{A}}_w\right)^{-1} \bar{\mathbf{A}}_w' \sum_{i=1}^n w_i \mathbf{B}_i \mathbf{u}_{it}.$$

Under the assumptions that $\mathbf{u}_{it}$ are weakly cross correlated, $\bar{\mathbf{A}}_w' \bar{\mathbf{A}}_w \rightarrow_p > 0$, as $n \rightarrow \infty$, then for *any* choice of weights $w_i$ that are granular it is possible to consistently estimate $\mathbf{f}_t$ up to intercepts and an $m \times m$ rotation matrix using $\bar{\mathbf{z}}_{wt} = (\Delta \bar{y}_{wt}, \mathbf{x}_{wt}')'$. More specifically, it is easily established that $\sum_{i=1}^n w_i \mathbf{B}_i \mathbf{u}_{it} = O_p(n^{-1/2})$, and we have $\mathbf{f}_t = \bar{\mathbf{a}}_{wf} + \bar{\mathbf{H}}_w \bar{\mathbf{z}}_{wt} + O_p(n^{-1/2})$, which can be used to eliminate the unobserved factors, $\mathbf{f}_t$, from Iran's output growth equation. Specifically, we obtain

$$\Delta y_t = \alpha_{yw} + \lambda \Delta y_{t-1} + \psi_0 s_t + \psi_1 s_{t-1} + \beta' \mathbf{x}_t + \theta_{yw} \Delta \bar{y}_{wt} + \theta_{xw}' \bar{\mathbf{x}}_{wt} + u_t + O_p(n^{-1/2}). \tag{4}$$

Hence, for $n$ sufficiently large, and considering that the Iranian economy is quite small relative to the rest of the world, the sanctions coefficients $\psi_0$, and $\psi_1$ can be identified by augmenting the output growth equations with the rest of the world average output growth, $\Delta \bar{y}_{wt}$, and the cross section weighted averages of the observed drivers of the rest of the world output growth, $\bar{\mathbf{x}}_{wt}$.

It is interesting to note that our approach does not favor selecting a pool of countries that are close to Iran, but recommends including all countries, possibly weighted for their relative importance in the world economy. Selecting specific countries could bias the results by restricting the number included in the construction of cross section averages. The rank condition, $rank\left(\bar{\mathbf{A}}_w' \bar{\mathbf{A}}_w\right) = m$, for a given $n$, and as $n \rightarrow \infty$, ensures that $\mathbf{f}_t$ has a reasonably pervasive effect on most economies which in turn allows us to use $\Delta \bar{y}_{wt}$, and $\bar{\mathbf{x}}_{wt}$ as a reliable proxy for $\mathbf{f}_t$.

The analysis of sanctions effects can also be extended to other macro variables such as inflation and

[15] See Pesaran (2006) for further details in a related context.

unemployment, and even to some key socio-economic indicators such as life expectancy, death rate or educational achievement, which has been made possible due to the unusually long duration of sanctions in the case of Iran.

# 4 Channels and dynamics of sanctions

It is also important to consider the main channels through which sanctions affect the economy, and to learn about the time profile of their effects. In the case of Iran, new sanctions, or even their announcement, have invariably led to a significant depreciation of the Iranian rial, reduced oil exports and foreign exchange revenues, followed by a sharp rise in price inflation and output losses within 3–6 months after the imposition of the new sanctions. The dynamic inter-relationships of exchange rate, money supply, inflation and output growth can be modelled using a structural vector autoregressive (*SVAR* for short) model augmented with the sanctions intensity variable, oil price changes and other control variables, denoted by $\bar{\mathbf{z}}_{wt}$ above.

We denote by $\mathbf{q}_t = \left(\Delta e_{ft}, \Delta m_t, \Delta p_t, \Delta y_t\right)'$ an $m \times 1$ (with $m = 4$) vector of endogenous domestic variables, where $\Delta e_{ft}$ represents the rate of change of free market foreign exchange rate,[16] $\Delta m_t$ is the growth rate of money supply, $\Delta p_t$ is the rate of inflation, and $\Delta y_t$ is real output growth.

To distinguish between different types of shocks and their implications for the Iranian economy, in our SVAR we assume the direction of causality goes from $\Delta e_{ft}$ to money supply growth, to inflation, and then to output growth, as represented by the ordering of the four endogenous variables in $\mathbf{q}_t$. Under this causal ordering, we are able to distinguish changes in $\mathbf{q}_t$ that are due to variations in the intensity of sanctions from those that are the result of domestic policy shocks. The assumed causal ordering can be justified in terms of relative speed with which the Iranian economy responds to crises. It is the value of the rial in free market that weakens first, followed by a potential expansion of liquidity, a rise in the price of imported commodities, before the real economy starts to adjust to higher prices and interest rates. Due to the relatively underdeveloped nature of money and capital markets, monetary policy tends to be accommodating by allowing a commensurate rise in liquidity.

[16] We also tried a weighted average of free market and official rate, and we found that the free market rate provides a more accurate and timely measure of the exchange rate movements for Iran given its higher responsiveness to sanctions. Our variable is expressed as Iran's rials per U.S. dollar.

In Equation (5), we look at the explanatory variables for $\mathbf{q}_t = \left(\Delta e_{ft}, \Delta m_t, \Delta p_t, \Delta y_t\right)'$

$$\mathbf{A}_0 \mathbf{q}_t = \mathbf{a}_q + \mathbf{A}_1 \mathbf{q}_{t-1} + \mathbf{A}_2 \mathbf{q}_{t-2} + \gamma_{0s} s_t + \gamma_{1s} s_{t-1} + \mathbf{D}_w \, \bar{\mathbf{z}}_{wt} + \varepsilon_t, \tag{5}$$

where $s_t$ is the sanctions intensity variable, and $\bar{\mathbf{z}}_{wt} = (\Delta p_t^0, \Delta \bar{y}_{wt}, \Delta \overline{req}_{wt}, \Delta \bar{r}_{wt}, grv_t, \Delta \bar{e}_{wt})'$ is a $k \times 1$ ($k = 6$) vector of control variables that includes: the rate of change of oil price, $\Delta p_t^0$, global output growth, $\Delta \bar{y}_{wt}$, global equity returns, $\Delta \overline{req}_{wt}$, global long term interest rates (in first difference), $\Delta \bar{r}_{wt}$, global realized volatility, $grv_t$, and the rate of change of the global real exchange rate, $\Delta \bar{e}_{wt}$.[17] To reflect the assumed causal ordering, we restrict $\mathbf{A}_0$ to be the following lower triangular matrix

$$\mathbf{A}_0 = \begin{pmatrix} 1 & 0 & \dots & 0 \\ -a^0_{\Delta m, \Delta e} & 1 & 0 & \vdots \\ -a^0_{\Delta p, \Delta e} & -a^0_{\Delta p, \Delta m} & 1 & 0 \\ -a^0_{\Delta y, \Delta e} & -a^0_{\Delta y, \Delta m} & -a^0_{\Delta y, \Delta p} & 1 \end{pmatrix},$$

where we expect $a^0_{\Delta p, \Delta e} \geq 0$, with inflation responding positively to a contemporaneous rise in $e_{ft}$ (rial depreciation). The contemporaneous impacts of $\Delta e_{ft}$, $\Delta m_t$ and $\Delta p_t$ on output growth are less clear cut, considering that all four structural equations are also conditioned on $s_t$, the variable representing sanctions intensity. The structural shocks, $\varepsilon_t = (\varepsilon_{\Delta e,t}, \varepsilon_{\Delta m,t}, \varepsilon_{\Delta p,t}, \varepsilon_{\Delta y,t})'$, are assumed to be serially uncorrelated with zero means, $\mathbb{E}(\varepsilon_t) = 0$, and the diagonal covariance matrix $\mathbb{E}(\varepsilon_t \varepsilon_t') = \Sigma = Diag\left(\sigma_{\Delta e, \Delta e}, \sigma_{\Delta m, \Delta m}, \sigma_{\Delta p, \Delta p}, \sigma_{\Delta y, \Delta y}\right)$. Since we condition on sanctions intensity and global indicators, the structural shocks can be viewed as "domestic" shocks attributed to policy changes that are unrelated to sanctions. Specifically, it is assumed that $\varepsilon_t$ are uncorrelated with $s_t$ and $\bar{\mathbf{z}}_{wt}$. Under these assumptions it is now possible to distinguish between the effects of a unit change in the sanctions variable, from domestic policy changes initiated by a unit standard error change to the domestic shocks, $\varepsilon_t$. Specifically, for contemporaneous effects we have $\partial \mathbf{q}_t / \partial s_t = \mathbf{A}_0^{-1} \gamma_{0s}$, and $\partial \mathbf{q}_t / \partial \varepsilon_{jt} = \sqrt{\sigma_{jj}} \mathbf{A}_0^{-1} \mathbf{e}_j$ where $\mathbf{e}_j$ ($j = \Delta e_f, \Delta m, \Delta p, \Delta y$) are the vectors of zeros except for their $j$-th component, which is one.

For the purpose of computing impulse responses and forecast error variance decompositions, we

[17] Details on data sources and the computation of the global variables are given in Section S.2 of the online supplement.

model $s_t$ and $\overline{\mathbf{z}}_{wt}$ as autoregressive processes:

$$s_t = a_s + \rho_s s_{t-1} + \eta_t, \tag{6}$$

$$\overline{\mathbf{z}}_{wt} = \mathbf{a}_{zw} + \mathbf{A}_{zw}\overline{\mathbf{z}}_{w,t-1} + \mathbf{v}_{wt}, \tag{7}$$

where the sanctions and global shocks, $\eta_t$ and $\mathbf{v}_{wt}$, are serially uncorrelated with zero means, and variances $\omega_s^2$ and $\Omega_w$. Combine equations (5), (6), and (7), we obtain the following SVAR model

$$\Psi_0 \mathbf{z}_t = \mathbf{a} + \Psi_1 \mathbf{z}_{t-1} + \Psi_2 \mathbf{z}_{t-2} + \mathbf{u}_t, \tag{8}$$

where $\mathbf{z}_t = (\mathbf{q}_t', s_t, \overline{\mathbf{z}}_{wt}')'$, $\mathbf{a} = \left(\mathbf{a}_q', a_s, \mathbf{a}_{zw}'\right)'$, $\mathbf{u}_t = (\varepsilon_t', \eta_t, \mathbf{v}_{wt}')'$, are $(m+k+1)\times 1$ vectors, and

$$\Psi_0 = \begin{pmatrix} \mathbf{A}_0 & -\gamma_{0s} & -\mathbf{D}_w \\ \mathbf{0} & 1 & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{I}_k \end{pmatrix}, \; \Psi_1 = \begin{pmatrix} \mathbf{A}_1 & \gamma_{1s} & \mathbf{0} \\ \mathbf{0} & \rho_s & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{A}_{zw} \end{pmatrix}, \; \Psi_2 = \begin{pmatrix} \mathbf{A}_2 & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & 0 & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} \end{pmatrix},$$

are $(m+k+1)\times(m+k+1)$ matrices. Standard techniques can now be applied to Equation (8) to obtain impulse response functions and error variance decompositions assuming the global shocks, $\mathbf{v}_{wt}$, are uncorrelated with domestic and sanctions shocks (namely $\varepsilon_t$, and $\eta_t$). This is a standard small open economy assumption which applies to the Iranian economy in particular since its relative size in the world economy is small and has been declining over the past forty years.

## 4.1 Impulse response analysis for SVAR model of the Iranian economy

The SVAR model can also be used to compute the time profile of the responses of the economy to shocks (sanction, domestic and foreign) using impulse response functions (IRFs). For the purpose of computing IRFs, we drop money supply growth and foreign variables except the world output growth, as none of these variables will prove to be statistically significant.

### 4.1.1 IRFs for domestic shocks

Our starting point is Equation (5) where $\mathbf{q}_t = \left(\Delta e_{ft}, \Delta m_t, \Delta p_t, \Delta y_t\right)'$, and there are four domestic shocks $\varepsilon_t = (\varepsilon_{\Delta e,t}, \varepsilon_{\Delta m,t}, \varepsilon_{\Delta p,t}, \varepsilon_{\Delta y,t})'$. The IRFs of one standard error shock to domestic shocks are given by

$$IRF_{\mathbf{q}}(h, \sqrt{\sigma_{jj}}) = E\left(\mathbf{q}_{t+h} \left| I_{t-1}, \varepsilon_{t,j} = \sqrt{\sigma_{jj}}\right.\right) - E\left(\mathbf{q}_{t+h} \left| I_{t-1}\right.\right), \text{ for } j = \Delta e_f, \Delta m, \Delta p, \Delta y,$$

where $h = 0,1,2...,H,$ is the horizon of the IRFs, $\sigma_{jj} = Var\left(\varepsilon_{jt}\right)$, and $I_{t-1}$ is the information set at time $t-1$. The IRFs compare the expected outcome of the shock (intervention) to an alternative counterfactual in the absence of the shock. Using the reduced form version of (5), we have $IRF_{\mathbf{q}}(h, \sqrt{\sigma_{jj}}) = \sqrt{\sigma_{jj}}(\mathbf{G}_h \mathbf{A}_0^{-1} \mathbf{e}_j)$, where

$$\mathbf{G}_\ell = \Phi_1 \mathbf{G}_{\ell-1} + \Phi_2 \mathbf{G}_{\ell-2}, \text{ for } \ell = 1,2,\ldots, \tag{9}$$

with $\mathbf{G}_{-1} = \mathbf{0}$, and $\mathbf{G}_0 = \mathbf{I}_m$, $\Phi_j = \mathbf{A}_0^{-1}\mathbf{A}_j$, for $j = 1,2$, and $\mathbf{e}_j$ is a $m \times 1$ selection vector of zeros except for its $j^{th}$ element which is unity. See Chapter 24 of Pesaran (2015). More specifically, the impulse response effects of a positive one standard error shock to the $j^{th}$ domestic variable, $\sqrt{\sigma_{jj}}$, on the $i^{th}$ variable at horizon $h = 0,1,...,H$, are given by $IRF_{ij}(h, \sqrt{\sigma_{jj}}) = \sqrt{\sigma_{jj}}(\mathbf{e}_i' \mathbf{G}_h \mathbf{A}_0^{-1} \mathbf{e}_j)$, for $i, j = \Delta e_f, \Delta m, \Delta p, \Delta y$.

### 4.1.2 IRFs for a shock to the sanctions intensity variable

Since global factors are assumed to be strictly exogenous to the Iranian economy and unrelated to sanctions, then without loss of generality the IRFs of sanction shocks can be obtained abstracting from the global shocks. Accordingly, using (5) and (6), the moving average ($MA$) representation of the domestic variables can be written as

$$\mathbf{q}_t = \mathbf{G}(1)\mathbf{A}_0^{-1}\left(\mathbf{a}_q + \frac{a_s}{1-\rho_s}\gamma_s\right) + \mathbf{b}(L)\eta_t + \mathbf{G}(L)\mathbf{A}_0^{-1}\varepsilon_t, \tag{10}$$

where $\gamma_s = \gamma_{0s} + \gamma_{1s}$, $\mathbf{b}(L) = \mathbf{G}(L)\mathbf{A}_0^{-1}(1-\rho_s L)^{-1}(\gamma_{0s} + \gamma_{1s}L)$, $\mathbf{G}(L) = \sum_{\ell=0}^{\infty} \mathbf{G}_\ell L^\ell$, and $\mathbf{G}_\ell$ is defined by the recursions in (9). Therefore, the responses of the $i^{th}$ domestic variable (the $i^{th}$ element of $\mathbf{q}_t$) to a positive one standard error shock to the sanctions intensity variable, $\omega_s$, are given by

$$IRF_i(h, \omega_s) = \omega_s(\mathbf{e}_i' \mathbf{b}_h), \; h = 0,1,...,H, \; i = \Delta e_f, \Delta m, \Delta p, \Delta y. \tag{11}$$

### 4.1.3 IRFs for a global factor shock

As noted earlier, we only consider the shock to the world output growth, $\Delta \bar{y}_{wt}$, as the global factor in our analysis, and consider the following general linear process for $\Delta \bar{y}_{wt}$

$$\Delta \bar{y}_{wt} = g_0 + c(L) v_{\Delta \bar{y},t}. \tag{12}$$

Since the sanctions intensity variable and the world output growth are assumed to be uncorrelated, abstracting from the sanctions intensity variable we can re-write (5),

$$\mathbf{A}_0\mathbf{q}_t = \mathbf{a}_q + \mathbf{A}_1\mathbf{q}_{t-1} + \mathbf{A}_2\mathbf{q}_{t-2} + \delta_w \Delta\bar{y}_{wt} + \varepsilon_t.$$

By combining (12) with the moving average representation of the above equation we have

$$\mathbf{q}_t = \mathbf{G}(1)\mathbf{A}_0^{-1}(\mathbf{a}_q + \delta_w g_0) + \kappa(L)v_{\Delta\bar{y},t} + \mathbf{G}(L)\mathbf{A}_0^{-1}\varepsilon_t, \tag{13}$$

where $\kappa(L) = \sum_{\ell=\mathbf{0}}^{\infty} \kappa_\ell L^\ell = \mathbf{G}(L)\mathbf{A}_0^{-1}\delta_w c(L)$, and $\mathbf{G}(L)$ is as defined above. Hence, the impulse responses of the $i^{th}$ element of $\mathbf{q}_t$ to a single period shock to world output growth is then given by

$$IRF_i(h, \omega_{\Delta\bar{y}}) = \omega_{\Delta\bar{y}}(\mathbf{e}_i'\kappa_h), \ h = 0, 1, ..., H, \ i = \Delta e_f, \Delta m, \Delta p, \Delta y, \tag{14}$$

where $\omega_{\Delta\bar{y}}^2$ is the variance of $v_{\Delta\bar{y},t}$.

## 4.2 Forecast error variance decompositions

Another useful measure of dynamic propagation of shocks is forecast error variance decompositions (FEVDs), which measure the proportion of forecast error variance of variable $q_{it}$ (say, output growth) which is accounted for by a particular domestic shock, $\varepsilon_{jt}$, at different horizons. We are particularly interested in estimating the relative importance of domestic shocks *vis-à-vis* sanctions or world output shocks in explaining output growth at different horizons. To obtain the FEVDs of both types of shocks, we first note that, by building on (10) and (13), the *n*-step ahead forecast errors for the vector of domestic variables, $\mathbf{q}_t$, is given by

$$\xi_t(n) = \sum_{\ell=0}^{n} \mathbf{b}_\ell \eta_{t+n-\ell} + \sum_{\ell=0}^{n} \kappa_\ell v_{\Delta\bar{y},t+n-\ell} + \sum_{\ell=0}^{n} \mathbf{G}_\ell \mathbf{A}_0^{-1} \varepsilon_{t+n-\ell},$$

where, as before, $\varepsilon_t$ is a $m \times 1$ (with $m = 4$) vector of domestic shocks. Using standard results from the literature, the *h*-step ahead FEVD of the $i^{th}$ variable in $\mathbf{q}_t$ which is accounted by the domestic shock $\varepsilon_{jt}$ is given by

$$\theta_{ij}(h) = \frac{\sigma_{jj} \sum_{\ell=0}^{h} \left(\mathbf{e}_i'\mathbf{G}_\ell\mathbf{A}_0^{-1}\mathbf{e}_j\right)^2}{\sum_{\ell=0}^{h} \mathbf{e}_i'\mathbf{G}_\ell\mathbf{A}_0^{-1}\Sigma\mathbf{A}_{\mathbf{0}}'^{-\mathbf{1}}\mathbf{G}_\ell'\mathbf{e}_i + \omega_s^2 \sum_{\ell=0}^{h} \mathbf{e}_i'\mathbf{b}_\ell\mathbf{b}_\ell'\mathbf{e}_i + \omega_{\Delta\bar{y}}^2 \sum_{\ell=0}^{h} \mathbf{e}_i'\kappa_\ell\kappa_\ell'\mathbf{e}_i}, \tag{15}$$

for $i, j = \Delta e_f, \Delta m, \Delta p, \Delta y$, and $\Sigma = Diag(\sigma_{\Delta e \Delta e}, \sigma_{\Delta m \Delta m}, \sigma_{\Delta p \Delta p}, \sigma_{\Delta y \Delta y})$. Similarly, the proportion of the forecast error variance of the $i^{th}$ variable due to sanctions intensity and world output growth shocks at horizon $h$ are given by

$$\theta_{is}(h) = \frac{\omega_s^2 \sum_{\ell=0}^{h} \mathbf{e}_i' \mathbf{b}_\ell \mathbf{b}_\ell' \mathbf{e}_i}{\sum_{\ell=0}^{h} \mathbf{e}_i' \mathbf{G}_\ell \mathbf{A}_0^{-1} \Sigma \mathbf{A}_0'^{-1} \mathbf{G}_\ell' \mathbf{e}_i + \omega_s^2 \sum_{\ell=0}^{h} \mathbf{e}_i' \mathbf{b}_\ell \mathbf{b}_\ell' \mathbf{e}_i + \omega_{\Delta \bar{y}}^2 \sum_{\ell=0}^{h} \mathbf{e}_i' \kappa_\ell \kappa_\ell' \mathbf{e}_i}, \tag{16}$$

and

$$\theta_{i\Delta \bar{y}}(h) = \frac{\omega_{\Delta \bar{y}}^2 \sum_{\ell=0}^{h} \mathbf{e}_i' \kappa_\ell \kappa_\ell' \mathbf{e}_i}{\sum_{\ell=0}^{h} \mathbf{e}_i' \mathbf{G}_\ell \mathbf{A}_0^{-1} \Sigma \mathbf{A}_0'^{-1} \mathbf{G}_\ell' \mathbf{e}_i + \omega_s^2 \sum_{\ell=0}^{h} \mathbf{e}_i' \mathbf{b}_\ell \mathbf{b}_\ell' \mathbf{e}_i + \omega_{\Delta \bar{y}}^2 \sum_{\ell=0}^{h} \mathbf{e}_i' \kappa_\ell \kappa_\ell' \mathbf{e}_i}, \tag{17}$$

respectively. Since all the shocks are assumed to be orthogonal, then it follows that $\sum_{j=1}^{m} \theta_{ij}(h) + \theta_{is}(h) + \theta_{i\Delta \bar{y}}(h) = 1$.

# 5 Measures of sanctions intensity

Sanctions against Iran have been imposed with different degrees of intensity over the past forty years. To account for both the prolonged nature of sanctions and their time-varying intensity, we construct "sanctions on" and "sanctions off" measures based on newspaper coverage of the imposition and the occasional lifting of sanctions. Newspaper coverage has been used in the literature and was initially formalized by Baker et al. (2016) for measuring the effects of economic uncertainty on macroeconomic aggregates. But, to our knowledge, the idea of using newspaper coverage to quantify sanctions intensity is new.

We consider six of the world's major daily newspapers, namely the New York Times, the Washington Post, the Los Angeles Times and the Wall Street Journal in the U.S., and the Guardian and the Financial Times in the U.K.. We then count the number of articles published in these newspapers that deal with sanctions and Iran.[18] We are careful not to confound our measures with articles that cover international sanctions against Iraq but also mention Iran. Sources and details of how the searches were carried out are provided in Section S.2.1 of the online supplement.

One can think of our approach as measuring a proxy for an underlying latent sanctions intensity

[18] The selected newspapers represent a balanced sample of the most-read and well-informed articles over the past forty years, and provide a good blend of both generalist press and those that focus on economic-finance issues. Also, by including two different geographic regions, we hope to cover a more diversified sample.

process. The true process generates a signal, part of which is captured in daily articles published in the six newspapers under consideration. To be specific, let $n_{jdt}$ be the number of articles published about sanctions on Iran in newspaper $j$ during day $d$ of month $t$, and denote the true (latent) sanctions intensity variable during month $t$ by $s_t^*$. The relationship between $n_{jdt}$ and $s_t^*$ is specified as

$$n_{jdt} = \theta_j s_t^* + \zeta_{jdt}, \tag{18}$$

where $\theta_j > 0$ is loading of newspaper $j$ on the true signal, $s_t^*$, and $\zeta_{jdt}$ is an idiosyncratic serially uncorrelated error term assumed to be distributed independently of the true signal, $s_{dt}^*$, with zero means and finite variances. Equation (18) could be viewed as a single factor model where $\theta_j$ is the newspaper-specific factor loading. The number of articles published in newspaper $j$ correlates with the true signal depending on the size of $\theta_j$ and the variance of the idiosyncratic term. Clearly, not all published articles capture the true signals, but by averaging across newspapers and different days in a given month it is possible to reduce the effects of the noise, $\zeta_{jdt}$, and obtain a consistent estimator of $s_t^*$, up to a scalar constant. Both simple and weighted averages can be used. Taking a simple average across the $J$ newspapers and the number of days, $D_t$, in month $t$, we have $\bar{n}_t = \bar{\theta}_J s_t^* + \bar{\zeta}_t$, where $\bar{n}_t = J^{-1} D_t^{-1} \sum_{j=1}^{J} \sum_{d=1}^{D_t} n_{jdt}$, $s_t^* = D_t^{-1} \sum_{d=1}^{D_t} s_{dt}^*$, and $\bar{\theta}_J = J^{-1} \sum_{j=1}^{J} \theta_j$. We considered 6 newspapers ($J = 6$) over a number of publishing days per month $D_t$, typically 26 days, resulting in about 156 data points over which to average. This in turn ensures that the idiosyncratic errors get diversified, and as a result the average error, $\bar{\zeta}_t$, becomes reasonably small. Specifically

$$\bar{\zeta}_t = J^{-1} D_t^{-1} \sum_{j=1}^{J} \sum_{d=1}^{D_t} \zeta_{jdt} = O_p\left(J^{-1} D_t^{-1}\right),$$

and we have $s_t^* = \bar{\theta}_J^{-1} \bar{n}_t + o_p(1)$.These monthly measures can then be time aggregated further to obtain quarterly or annual series which are then used to identify the effects of $s_t^*$ (up to the scaling factor $\bar{\theta}_J^{-1}$) in our macro-econometric model. We could also consider a weighted average version of $\bar{n}_t$ along the lines suggested in the literature, where the number of newspaper articles (the raw count) is weighted by the inverse of their respective standard deviations, $\hat{\sigma}_{jT}$, computed over the full data set, using $\hat{\sigma}_{jT} = \sqrt{(T-1)^{-1} \sum_{t=1}^{T} \left(\bar{n}_{jt} - \bar{n}_j\right)^2}$, $\bar{n}_{jt} = D_t^{-1} \sum_{d=1}^{D_t} n_{jdt}$, and $\bar{n}_j = T^{-1} \sum_{t=1}^{T} \bar{n}_{jt}$. See Baker et al. (2016) and Plante (2019). But, as reported in Figure S.1 of the online supplement, the simple and weighted averages, after being suitably scaled, are very close in the case of our application.

Although most sanctions news has been about imposing new or tightening old sanctions, there are some isolated periods where sanctions have been lifted, as in 1981 after the release of the U.S. hostages, and over the period 2016q1–2018q2 after the implementation of JCPOA. Accordingly, we construct two sanctions measures: an 'on' measure, denoted by $s_{t,on}$, and an 'off' measure, denoted by $s_{t,off}$, and we normalize them such that they both lie between 0 and 1, with 1 representing the maximum sanctions intensity over the full sample. We then define a net sanctions measure as $s_t = s_{t,on} - w \times s_{t,off}$, where $w > 0$ represents the weight attached to the sanctions off indicator compared to the sanctions on indicator. The weight, $w$, is estimated to be $\widehat{w} = 0.4$ using a grid search method over values of $w \in (0,1)$.[19]

Figure 2 displays the quarterly estimates of $s_t$ over the period from 1989q1 to 2020q3, which takes its maximum value at the end of 2011 when Iran was sanctioned simultaneously by the U.N., the U.S. and the E.U.. Important historical events are annotated in the lower part of the figure, while specifics of particular sanctions are shown on the upper part of the figure.

The fact that intensity of sanctions against Iran has been quite varied can be clearly seen from Figure 2. Most notably there are three major spikes in sanctions intensity. The first is in 2006 after Ahmadinejad was elected and Iran began its uranium enrichment program**,** when the U.S. passed the "Iran Freedom and Support Act", which extended the coercive measures against Iran – most notably secondary sanctions on non-U.S. corporations and institutions doing business with Iran and very strict sanctions related to investments in the energy sector. An even larger spike occurs between 2011 and 2012, when the Obama administration joined efforts with the United Nations and the European Union to tighten the sanctions even further with the aim of bringing Iran to negotiations over the nuclear program. The U.S. passed stiff measures at the end of December 2011 under the "National Defense and Authorization Act for Fiscal Year 2012", with Iran threatening to block oil shipments through the Strait of Hormuz as a response. At the same time the E.U. initiated a total disconnect of Iranian financial institutions from the international payments system (*SWIFT*) in March 2012,[20] while the U.N. proceeded to extend the mandates of their previous resolutions between June 2011 and June 2012. The third, and most recent, spike is registered

[19] Section S.2.1 in the data appendix of the online supplement provides further details on the estimation of $\widehat{w}$.

[20] SWIFT stands for the "Society for Worldwide Interbank Financial Telecommunications", and it is a vast and secure network used by banks and other financial institutions to operate financial transactions across the globe.

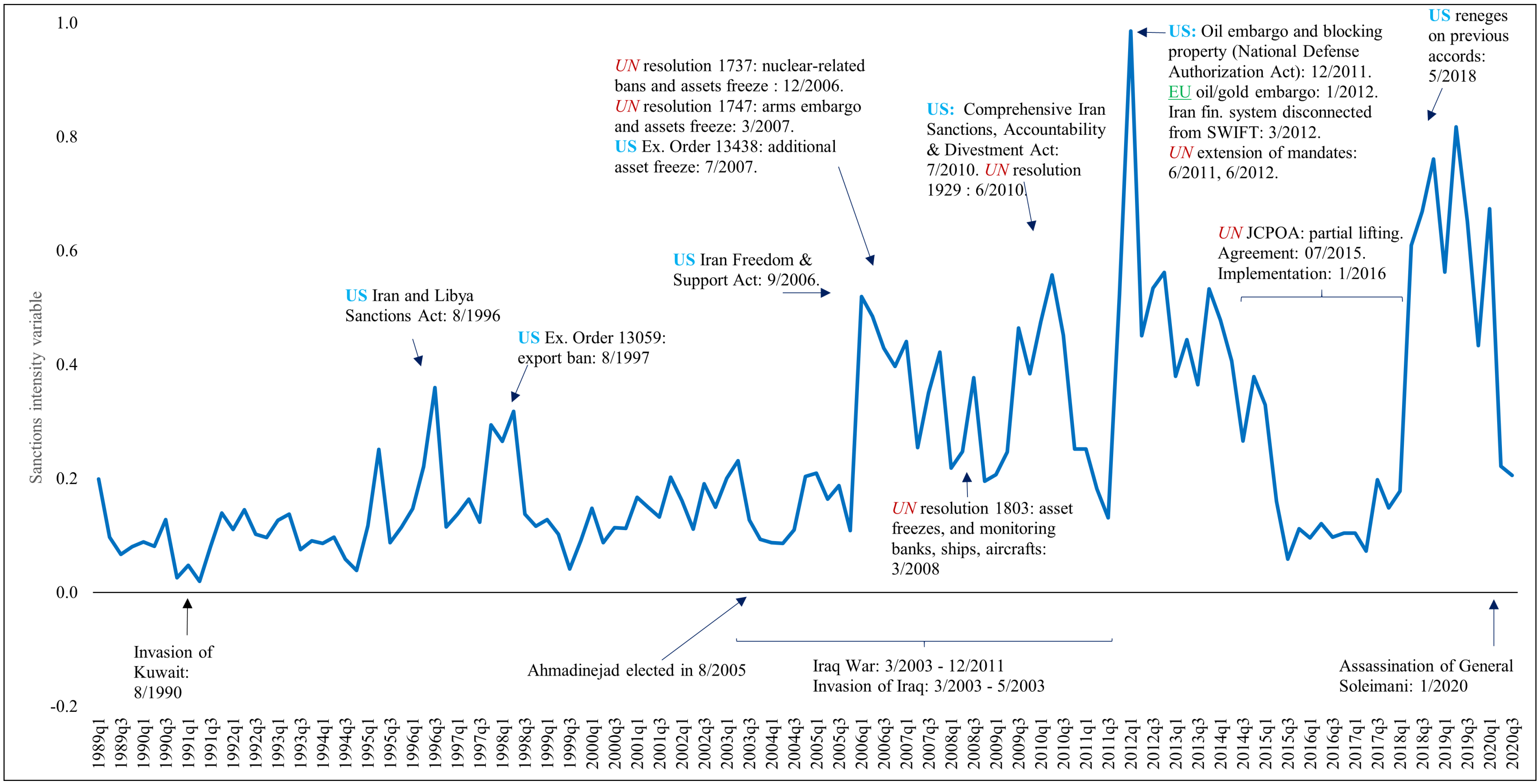
in 2018q2 after Trump decided to unilaterally withdraw the U.S. from the JCPOA accord and begin a strategy of "maximum pressure". There are also minor spikes in 1996 when the Clinton administration signed the "Iran and Libya Sanctions Act", and in 1997 when the U.S. introduced an export ban to reduce the threat of potential weapons of mass destruction being built, and in 2010 when the *CISADA* ("Comprehensive Iran Sanctions Accountability and Divestment Act") was signed into law and the U.N. Security Council passed the fourth round of sanctions against Iran with its 1929 resolution.

Lows of the sanctions intensity variable are recorded during the reconstruction period under President Rafsanjani and the pragmatic rule under Khatami's administration, and more recently over the period between the JCPOA agreement in August 2015 and January 2018, when the U.S. unilaterally withdrew from the agreement. Table 2 provides summary statistics (minimum, median, mean, maximum and standard deviations) of $s_t$ over a number of sub-periods. A number of interesting observations follow from this table. First, the summary statistics for $s_t$ over the low sanctions periods under Rafsanjani and Khatami are very close to those recorded for the period 2015q1–2018q1 when sanctions were partially lifted after JCPOA. Second, the peak of sanctions occurred during the internationally coordinated efforts of 2011/2012 rather than after 2018, when the U.S. began their "maximum pressure" strategy under Trump and Bolton. In the period after 2018q2, the degree of intensity of our indicator is 82 per cent of its peak in 2011. However, after 2018 the intensity of sanctions against Iran seems to have been much more persistent: the mean and median are higher during the 2018q2–2020q3 period than during 2012q1–2014q4. Finally, we notice that after the Iran-Iraq War, the median of the sanctions intensity has been only two thirds of the mean: 0.16 vs. 0.24. This feature stems from the several tail events that characterize the series of sanctions against Iran, and as an overall measure the median is to be preferred to the mean.

For the analysis of the effects of sanctions on Iran, it is also important to note that $s_t$ shows a considerable degree of persistence over time. When sanctions are intensified they tend to remain high for some time before subsiding. Table S.4 in the online supplement provides estimates of first- and second-order autoregressive processes (AR) fitted to $s_t$, and shows that an AR(1) model captures well the sanctions intensity process, with a relatively large and highly significant AR coefficient, namely $0.743\ (0.059)$.

Finally, as a robustness check we also attempted to create an alternative measure of sanctions inten-

Figure 2: Sanctions intensity variable over the period 1989q1–2020q3




**Notes**: Major events related to the Middle East are indicated by arrows below the *x*-axis. Major sanctions episodes related to Iran are indicated by arrows above the *x*-axis. See Section S.2.1 in the data appendix of the online supplement for details on the construction of the sanctions intensity variable.

Table 2: Descriptive statistics of the sanctions intensity variable over relevant time periods

| | Time period | Min | Median | Mean | Max | St. Dev. |
|---|---|---|---|---|---|---|
| Rafsanjani & Khatami presidencies | 1989q3–2005q2 | 0.02 | 0.12 | 0.13 | 0.36 | 0.07 |
| Ahmadinejad presidency | 2005q3–2013q2 | 0.11 | 0.39 | 0.38 | 1.0 | 0.17 |
| U.N./U.S. max sanctions | 2012q1–2014q4 | 0.27 | 0.45 | 0.48 | 1.0 | 0.18 |
| JCPOA agreement | 2015q1–2018q1 | 0.06 | 0.11 | 0.14 | 0.33 | 0.07 |
| U.S. "maximum pressure" | 2018q2–2020q3 | 0.21 | 0.63 | 0.56 | 0.82 | 0.21 |
| *Full sample* (post Iran-Iraq War) | 1989q1–2020q3 | 0.02 | 0.16 | 0.24 | 1.0 | 0.19 |

**Notes:** See Section S.2.1 in the data appendix of the online supplement for details on the construction of the sanctions intensity variable.

sity based on the number of Iranian entities being sanctioned by the U.S.. We used the U.S. Treasury data set on entries and exits of sanctioned companies, individuals and vessels. We were able to build an indicator from 2006 to present. Although the two measures (newspaper coverage and U.S. Treasury data) capture the sanctions phenomenon from different perspectives, they correlate rather well at 38 per cent. For further details see Section S.2.1 of the online supplement.

# 6 A time series structural model of Iran

Equipped with the sanctions intensity measure, $s_t$, we now report the results of estimating the SVAR model set out in Section 4 with the exchange rate variable, $\Delta e_{ft}$, included first followed by money supply growth, $\Delta m_t$, inflation, $\Delta p_t$, and output growth, $\Delta y_t$. We estimated the four equations of the SVAR model including different sub-sets of the control variables: world output growth, changes in international oil prices, global realized volatility, world real equity returns, changes in long term interest rates, and global real exchange rate changes against U.S. dollar. The full set of regressions results are provided in Tables S.6a to S.6d in the online supplement. As can be seen, none of the other control variables play a significant role in our analysis with the exception of the world output growth. Accordingly, in Table 3 we provide estimates of SVAR model including only the world output growth ($\Delta\bar{y}_{wt}$) as a control variable.

The estimates of the effects of sanctions on the free market foreign exchange rate variable, $\Delta e_{ft}$, are given under Column (1).[21] We first note that it is moderately persistent with a persistent coefficient of 0.33, partly reflecting inefficiencies in Iran's foreign exchange market. Second, we observe that the rial

[21] Note that the exchange rate is expressed as the number of Iranian rials per one U.S. dollar, and therefore a rise in the exchange rate variable corresponds to a depreciation of the rial.

depreciates strongly in the same quarter in which sanctions are raised. The median fall in its value is between 4.7 and 5 per cent per quarter.[22] However, there is a significant degree of overshooting, with the sanctions variable having the opposite effect on exchange rate after one quarter. The rial appreciates by about 3.8 per cent in the following quarter, resulting in a less pronounced overall impact of sanctions on the rial depreciation of around 2.5 per cent per quarter, or 10 per cent per annum, which is still quite substantial.[23] As can be seen from Table S.6a of the online supplement, these estimates are remarkably stable and statistically significant at the 1 per cent level across all specifications regardless of the number of global control variables included in the regression equation. In fact, none of the lagged domestic variables (inflation, money supply growth, and output growth) have a statistically significant effect on the exchange rate, and only foreign output growth proves to be statistically significant at 10 per cent level. Most notably, changes in international oil prices do not have a statistically significant impact on the exchange rate, which could be due to the fact that once we condition on the sanctions variable, a rise in oil prices is less likely to benefit Iran when oil exports are severely limited due to sanctions. The adjusted $R^2$ of the exchange rate equations with world output growth included is around 24 per cent. This is high by the standard of exchange rate equations, and is partly explained by the presence of the contemporaneous sanctions variable in the regression. Its use for prediction requires predicting the sanctions variable which adds another layer of uncertainty. It is also noteworthy that there is no statistically significant evidence of residual serial correlation in any of the exchange rate equations in Table S.6a. Lack of residual serial correlation is important for a valid impulse response analysis and forecast error variance decompositions that we shall consider below.

The estimates for the money supply growth ($\Delta m_t$) equation are summarized in Column (2) of Table 3. As can be seen, only lagged money supply growth is significant. It is also interesting that the coefficient of lagged money supply growth has a negative sign suggesting some overshooting of money supply growth which is then reversed in the subsequent period. Notably, we do not find any feedback effects from inflation to money supply growth.

The estimates for inflation ($\Delta p_t$) are summarized in Column (3) of Table 3. As discussed in Section

[22] To assess the effect of sanctions, we need to multiply all coefficients related to $s_t$ and $s_{t-1}$ by the median $(0.16)$. See Table 2. In this way, we can assess the difference with respect to a case with no sanctions $(s_t = 0)$. We consider the median rather than the average intensity to maintain a conservative approach given that $s_t$ follows a non-Gaussian process with several outliers.

[23] Such overshooting is well-known in the international finance literature. See, for example, Dornbusch (1976).

2, inflation in Iran has been persistently high over the past forty years, and to capture its persistence it proved necessary to include $\Delta p_{t-2}$, as well as $\Delta p_{t-1}$ in the regression equation. It does not seem necessary to include second order lags of other variables in the inflation equation.[24] Perhaps not surprisingly, the estimates also show that exchange rate depreciation is an important determinant of inflation in Iran, a factor which is statistically significant and quantitatively important. The immediate effect of one per cent depreciation of the free market exchange rate is to raise prices by around 0.15 to 0.16 per cent, as many imported goods items tend to rise with the fall in exchange rate. Sanctions affect inflation indirectly through the exchange rate as well as directly, but the direct effects of sanctions do not last and the net direct effects of sanctions on inflation seem to be negligible. It is also interesting and quite surprising that money supply growth or lagged output growth do not seem to have any significant direct effects on inflation. But we do find some evidence of global output growth positively affecting inflation, a kind of international Phillips curve effect that leads to higher international prices that are in turn reflected in Iran's import prices and hence domestic inflation.

Finally, Column (4) of Table 3 provides the results for real output growth. Output growth in Iran is negatively autocorrelated, with a coefficient estimated to be around $-0.195$ which is statistically significant. This contrasts the positively autocorrelated output growth observed for many other countries. The sanctions intensity variable affects output growth with a lag, as it takes a few months for different sectors of the economy to adjust to sanctions. After only one quarter, the effect of sanctions on output growth is statistically highly significant. [25] Within two quarters the regression predicts Iran's output growth to slow down by about 0.9 per cent per quarter (3.6 per cent per annum). In addition to this direct effect, sanctions also influence output growth through exchange rate depreciation, which is also highly statistically significant. This indirect effect amounts to around 0.125 per cent per quarter drop in output growth when the rial depreciates by one per cent. Output growth is also negatively affected by lagged inflation, which highlights the adverse effects of high and persistent inflation without any short term Phillips curve type of trade off between inflation and output growth. Interestingly enough, none of the global factors seem to have any significant effects on Iran's output growth, partly due to Iran's

[24] See also Table S.6c of the online supplement where different sub-sets of control variables are also included in the regressions for the inflation equation.

[25] Table S.6d in the online supplement proves this to be a stable finding under different specifications when we allow for a variety of control variables.

relative economic and financial isolation from the rest of the global economy. See Table S.6d of the online supplement for further details.

Table 3: Quarterly estimates of the SVAR model of Iran with domestic variables ordered as: foreign exchange rate returns, money supply growth, inflation, and output growth, estimated over the period 1989q1–2020q1

| | $\Delta e_{ft}$ | $\Delta m_t$ | $\Delta p_t$ | $\Delta y_t$ |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| $s_t$ | 0.303*** | −0.001 | −0.033*** | 0.021 |
| | (0.061) | (0.024) | (0.012) | (0.025) |
| $s_{t-1}$ | −0.245*** | 0.011 | 0.037*** | −0.058** |
| | (0.063) | (0.024) | (0.013) | (0.026) |
| $\Delta e_{ft}$ | | −0.015 | 0.162*** | −0.125*** |
| | | (0.033) | (0.017) | (0.044) |
| $\Delta m_t$ | | | −0.032 | 0.097 |
| | | | (0.048) | (0.094) |
| $\Delta p_t$ | | | | 0.341* |
| | | | | (0.180) |
| $\Delta \bar{y}_{wt}$ | −2.059* | 0.135 | 0.721*** | −0.049 |
| | (1.123) | (0.405) | (0.209) | (0.432) |
| $\Delta e_{f,t-1}$ | 0.341*** | −0.040 | −0.010 | 0.033 |
| | (0.090) | (0.034) | (0.019) | (0.035) |
| $\Delta m_{t-1}$ | 0.350 | −0.289*** | −0.038 | −0.020 |
| | (0.250) | (0.090) | (0.048) | (0.095) |
| $\Delta p_{t-1}$ | −0.376 | 0.132 | 0.490*** | −0.496*** |
| | (0.331) | (0.118) | (0.086) | (0.165) |
| $\Delta y_{t-1}$ | −0.126 | −0.064 | 0.023 | −0.195** |
| | (0.242) | (0.086) | (0.046) | (0.088) |
| $\Delta p_{t-2}$ | | | 0.174** | |
| | | | (0.076) | |
| Residual serial | 6.013 | 7.165 | 8.236 | 7.108 |
| correlation test | [0.198] | [0.127] | [0.083] | [0.130] |
| Adjusted $R^2$ | 0.240 | 0.047 | 0.669 | 0.129 |

**Notes**: The variables are ordered as: $\Delta e_{ft}$, $\Delta m_t$, $\Delta p_t$, and $\Delta y_t$, where: $\Delta e_{ft} = \ln(E_{ft}/E_{f,t-1})$, $E_{ft}$ is the quarterly rial/U.S. dollar free market exchange rate; $\Delta m_t = \ln(M_{2t}/M_{2,t-1})$, $M_{2t}$ is obtained by summing the aggregates $M1$ and "quasi-money"; $\Delta p_t = \ln(P_t/P_{t-1})$, $P_t$ is the quarterly consumer price index of Iran; $\Delta y_t = \ln(Y_t/Y_{t-1})$, $Y_t$ is the quarterly real output of Iran. $s_t$ is the quarterly sanctions intensity variable. $\Delta \bar{y}_{wt}$ is the quarterly world output growth, computed as $\bar{y}_{wt} = \sum_{i=1}^{n} w_i y_{it}$, with $\{y_{it}\}_{i=1}^{n}$ being the natural log of real output for 33 major economies, and $\{w_i\}_{i=1}^{n}$ are GDP-PPP weights. Numbers in parentheses are standard errors, and those in square brackets are p-values. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. "Residual serial correlation test" is the Breusch–Godfrey LM test of serially uncorrelated errors with lag order of the test set to 4.
See Sections S.2.1, S.2.2, and S.2.3 in the data appendix of the online supplement for details on the construction of the sanctions intensity variable, calendar conversions, and sources of the data used. Regressions results that include other global control variables (e.g. oil prices) are provided in Tables S.6a–S.6d in the online supplement.

It is also worth noting that our main findings are not much affected by re-ordering of the domestic variables. In Section S.4 of the online supplement we provide results of estimating the SVAR model in (5), with two other orderings of the domestic variables, namely $(\Delta p_t, \Delta e_{ft}, \Delta m_t, \Delta y_t)$, and

$\left(\Delta m_t, \Delta e_{ft}, \Delta p_t, \Delta y_t\right)$. The results are summarized in Tables S.7a to S.7d and S.8a to S.8d, respectively, and clearly show that money supply growth plays a minimal role in determination of inflation and exchange rate variations, and exchange rate remains the primary driver of inflation and output growth.

Overall sanctions have affected Iran in a number of ways and through different direct and indirect channels, the most important of which is the exchange rate depreciation. The exchange rate depreciation itself could have its roots in persistently high levels of inflation, coupled with a reduction in oil revenues and anticipated decline in private sector activity. The currency depreciation in turn leads to higher import prices and lower economic growth. We also find that the *direct* effect of sanctions on inflation is rather small, compared to an average annual inflation norm of around 18 per cent in Iran (See Table 1).

Money supply growth seems to follow patterns which are neither related to sanctions nor to any of the domestic variables, notably inflation, which could be due to the underdevelopment of capital and money markets in Iran, as highlighted recently by Mazarei (2019). These results seem quite robust to other measures of liquidity such as M1 or private sector credit.[26]

## 6.1 Impulse response analysis

The estimates of the individual equations provided in Table 3 provide a snap-shot of how sanctions interact with some of the key macroeconomic variables. However, given the dynamic and simultaneous nature of the model, to fully understand and evaluate the nature and consequences of these interactions we need to resort to impulse response functions (*IRFs*) and forecast error variance decompositions (*FEVDs*) discussed in Sections 4.1 and 4.2, respectively. We have seen that money supply growth does not play much of a role in the determination of inflation and output growth, and is hardly affected by sanctions. Also, amongst the control variables, only foreign output growth seems to exert statistically significant effects on inflation and output growth. For these reasons, to compute IRFs and FEVDs we will be focussing on a parsimonious SVAR model without the money supply growth, and only including $\Delta\bar{y}_{wt}$ as the control variable. We also use AR(1) models for $s_t$ and $\Delta\bar{y}_{wt}$ to capture the dynamics of these exogenous processes.[27]

[26] Estimates based on these alternative measures of liquidity are available upon request.

[27] Time series evidence in support of our choice of AR(1) specifications for $s_t$ and $\Delta\bar{y}_{wt}$ are provided in Tables S.4 and S.5 of the online supplement. It is also worth noting that the assumed AR(1) processes for $s_t$ and $\Delta\bar{y}_{wt}$ only affect the IRFs and FEVDs, and do not affect the estimates of the SVAR model.

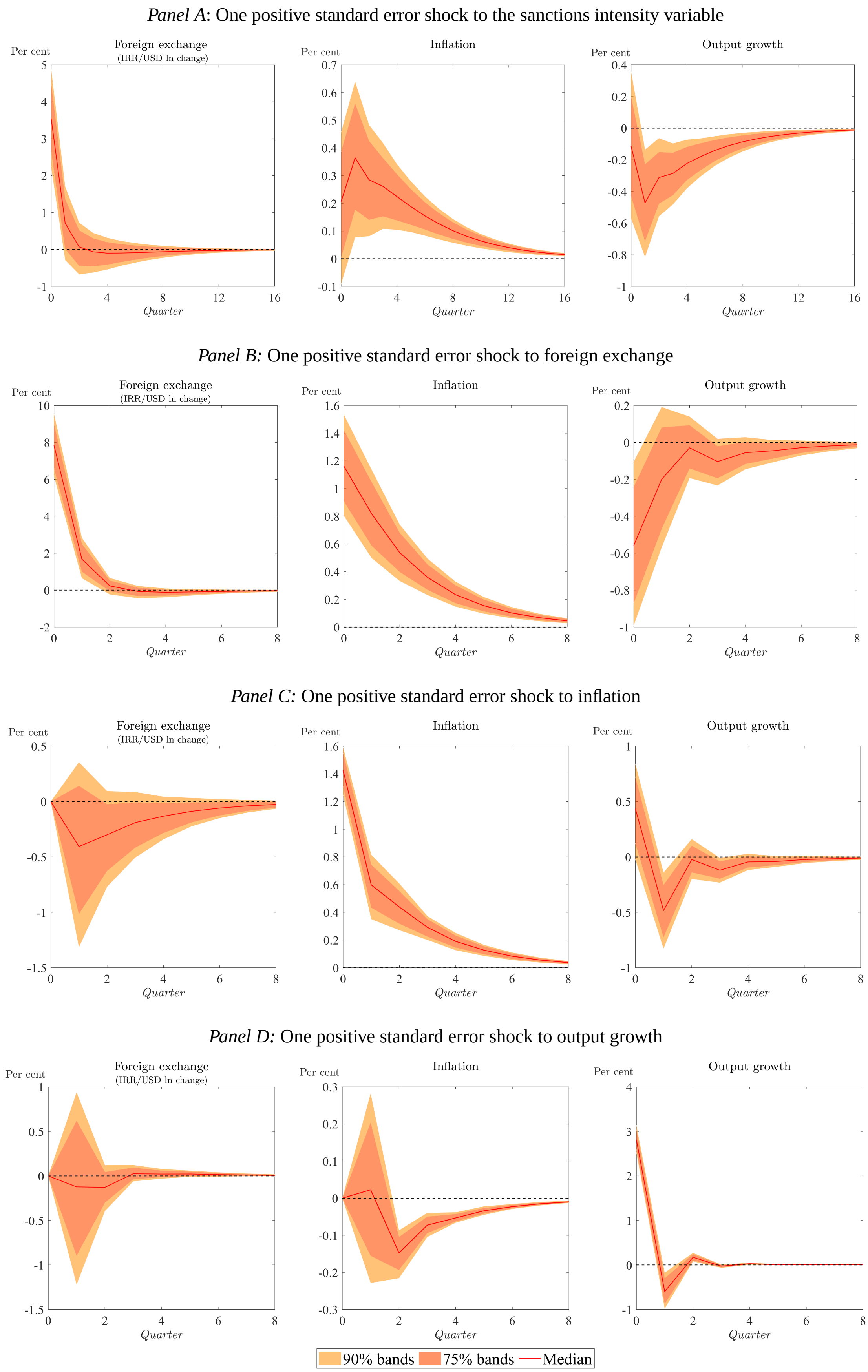
The IRFs for positive one standard error (s.e.) shocks to the three sanction domestic shocks are displayed in Figure 3. *Panel A* of this figure shows the results for the sanction shock.[28] A single quarter shock to sanctions intensity causes the foreign exchange rate to depreciate by about 3 per cent in the same quarter, but its effects are rather short lived and become statistically insignificant two quarters after the shock. For inflation and output growth the effects of the sanction shock last much longer. Its effects on inflation are particularly persistent and last at least for four years after the shock, although its magnitude is relatively small: 0.3 per cent increase per quarter in the first year. The effects of sanction shock on output growth, on the other hand, are much larger in size. A single period one standard error shock to sanctions causes output growth to fall by more than 0.4 per cent per quarter (1.6 per cent per annum). The loss in output growth is still close to 0.2 per cent per quarter two years after the shock.

The results for the foreign exchange rate shock (independent of the sanction shock) is given in *Panel B* of Figure 3. This shock generates a sizeable and precisely estimated effect (of around 8 per cent per quarter) on exchange rate, but similar to the effects of the sanction shock, it does not last long and its effects dissipate very quickly after two quarters. The exchange rate shock raises inflation on impact by around 1.2 per cent per quarter, and then starts to fall and vanishes completely after about two years. The same is not true of real output growth. The direct effects of foreign exchange shock on output growth are negative and statistically significant but small in magnitude, around $-0.50$ per cent on impact, which then moves towards zero very quickly.

*Panel C* of Figure 3 gives the results for an inflation shock (for example, due to a domestic expansionary policy). Again, because of the highly persistent nature of inflation in Iran, the most pronounced effects of the inflation shock is on inflation itself, raising inflation by 1.5 per cent per quarter on impact and then falling gradually to zero after two years. Interestingly, the effect of inflation shock on exchange rate is not statistically significant, suggesting that the causal link between them is from exchange rate to inflation and not *vice versa*. Compare the IRFs for exchange rate and inflation in Panels B and C of Figure 3. The effects of inflation shock on output growth are positive on impact but small in magnitude, and reverse quickly after one quarter, suggesting that it might not be possible to increase output by expansionary policies.

[28] One standard deviation is equal to 0.125. See Table S.4.

Figure 3: Impulse responses of the effects of sanctions and domestic shocks on foreign exchange, inflation, and output growth



Finally, the IRFs of the effects of a positive shock to output growth are displayed in *Panel D* of Figure 3. A positive output shock could be due to technological advance or fundamental reforms that reduce economic distortions and enhance production opportunities. The output shock seems to have little impact (in short or medium term) on exchange rate, which seems to be primarily driven by sanctions and its own dynamics. But the positive output shock has a positive, but rather moderate, effect on inflation, lowering inflation by 0.1 per cent per quarter after two quarters. The primary effects of the output shock are on output itself, raising output by 2.8 per cent per quarter on impact before losing momentum in less than a year. The initial very large increase in output is somewhat of an over-reaction which is then corrected slightly, yet providing a net 2 per cent rise in output within the year of the shock. Once again this result highlights the importance of supply side policies for improving Iran's output growth in the long run.[29]

The impulse response analysis confirms some of the preliminary conclusions set out in Section 6. Sanctions have their most impact on free market exchange rate, and to a lesser extent on output growth. Inflation has its own dynamics and is hardly affected by sanctions. The roots of high and persistent inflation must be found in domestic economic mismanagement. Also, sanctions do adversely affect output growth after one quarter but such effects are short lived.

## 6.2 Forecast error variance decompositions

We now turn to a quantification of the relative importance of sanctions as compared to the three domestic shocks and the foreign output shock. Table 4 presents the results.[30] *Panel A* of the table gives the results for the foreign exchange variable. Not surprisingly, foreign exchange shocks are the most important, and account for 82 per cent of forecast error variance on impact and decline only slightly, falling to 79 per cent after 5 quarters. Sanctions shock accounts for 16 per cent of the variance, with the other shocks contributing very little. Therefore, isolated sanctions do not drive Iran's exchange rate, and only become a dominant force if we consider prolonged periods over which sanction shocks are in place with the same intensity.

[29] Figure S.3 in Section S.4 of the online supplement provides an illustration of how the domestic variables respond to a positive global output growth shock. It is found that the effects are statistically insignificant, except for a small appreciation of the Iranian rial in the first quarter.

[30] FEVDs are computed using equations (15), (16), and (17).

Table 4: Forecast error variance decomposition for domestic variables in the SVAR model with a single shock to sanctions

*Panel A:* Forecast error variance decomposition for foreign exchange

| *Quarter* | Proportion explained by a shock to: | | | | |
|---|---|---|---|---|---|
| *ahead* | $s_t$ | $\Delta e_{ft}$ | $\Delta p_t$ | $\Delta y_t$ | $\Delta \bar{y}_{wt}$ |
| 0 | 0.16 | 0.82 | 0.00 | 0.00 | 0.02 |
| 1 | 0.16 | 0.80 | 0.00 | 0.00 | 0.03 |
| 2 | 0.16 | 0.80 | 0.01 | 0.00 | 0.03 |
| 3 | 0.16 | 0.80 | 0.01 | 0.00 | 0.03 |
| 4 | 0.16 | 0.80 | 0.01 | 0.00 | 0.03 |
| 5 | 0.16 | 0.79 | 0.01 | 0.00 | 0.03 |
| 6 | 0.16 | 0.79 | 0.01 | 0.00 | 0.03 |
| 7 | 0.16 | 0.79 | 0.01 | 0.00 | 0.03 |
| 8 | 0.16 | 0.79 | 0.01 | 0.00 | 0.03 |

*Panel B:* Forecast error variance decomposition for inflation

| *Quarter* | Proportion explained by a shock to: | | | | |
|---|---|---|---|---|---|
| *ahead* | $s_t$ | $\Delta e_{ft}$ | $\Delta p_t$ | $\Delta y_t$ | $\Delta \bar{y}_{wt}$ |
| 0 | 0.01 | 0.43 | 0.54 | 0.00 | 0.02 |
| 1 | 0.03 | 0.48 | 0.47 | 0.00 | 0.02 |
| 2 | 0.05 | 0.49 | 0.44 | 0.00 | 0.02 |
| 3 | 0.06 | 0.50 | 0.43 | 0.00 | 0.02 |
| 4 | 0.06 | 0.50 | 0.42 | 0.00 | 0.02 |
| 5 | 0.07 | 0.50 | 0.42 | 0.00 | 0.02 |
| 6 | 0.07 | 0.50 | 0.42 | 0.00 | 0.02 |
| 7 | 0.07 | 0.50 | 0.42 | 0.00 | 0.02 |
| 8 | 0.07 | 0.50 | 0.42 | 0.00 | 0.02 |

*Panel C:* Forecast error variance decomposition for output growth

| *Quarter* | Proportion explained by a shock to: | | | | |
|---|---|---|---|---|---|
| *ahead* | $s_t$ | $\Delta e_{ft}$ | $\Delta p_t$ | $\Delta y_t$ | $\Delta \bar{y}_{wt}$ |
| 0 | 0.00 | 0.04 | 0.03 | 0.93 | 0.00 |
| 1 | 0.02 | 0.04 | 0.05 | 0.88 | 0.00 |
| 2 | 0.04 | 0.04 | 0.05 | 0.87 | 0.00 |
| 3 | 0.04 | 0.04 | 0.05 | 0.86 | 0.00 |
| 4 | 0.05 | 0.04 | 0.05 | 0.85 | 0.00 |
| 5 | 0.05 | 0.04 | 0.05 | 0.85 | 0.00 |
| 6 | 0.05 | 0.04 | 0.05 | 0.85 | 0.00 |
| 7 | 0.05 | 0.04 | 0.05 | 0.85 | 0.00 |
| 8 | 0.05 | 0.04 | 0.05 | 0.85 | 0.00 |

**Notes**: $s_t$ is the quarterly sanctions intensity variable. $\Delta e_{ft} = \ln(E_{ft}/E_{f,t-1})$, $E_{ft}$ is the Iran rial/U.S. dollar quarterly free market exchange rate. $\Delta p_t = \ln(P_t/P_{t-1})$, $P_t$ is the quarterly consumer price index of Iran. $\Delta y_t = \ln(Y_t/Y_{t-1})$, $Y_t$ is the quarterly real output of Iran. $\Delta \bar{y}_{wt}$ is the quarterly world output growth: $\bar{y}_{wt} = \sum_{i=1}^{n} w_i y_{it}$, with $\{y_{it}\}_{i=1}^{n}$ being the natural log of real output for 33 major economies, and $w_i$ the GDP-PPP weights.

See Sections S.2.1, S.2.2, and S.2.3 in the data appendix of the online supplement for details on the construction of the sanctions intensity variable, calendar conversions, and sources of the data used.

The FEVDs of inflation, reported in *Panel B* of Table 4, show that foreign exchange and inflation shocks account for the bulk of the variance, with sanction shocks accounting for the remainder. Domestic and foreign output shocks make little contribution. On impact, inflation shock accounts for 54 per cent of the variance, flattening out at 42 per cent after 4 quarters. In contrast, the contribution of the foreign exchange shock rises from 43 per cent on impact to 50 per cent after 3 quarters. The contribution of the sanction shock is not particularly large, and starts at 1 per cent, but rises to 7 per cent after 4 quarters. Once again we see that inflation and exchange rates in Iran are mainly driven by domestic factors. But sanctions effects could accumulate very quickly if we consider sanctions being in place over a prolonged period of time.

Finally, the FEVDs of output growth are reported in *Panel C* of Table 4. As can be seen, the output shock is by far the most important shock and accounts for 93 per cent of forecast error variance of output growth on impact and falls only slightly to 85 per cent after 4 quarters. In line with our estimates, sanctions shocks do not affect output growth on impact, and end up explaining only 5 per cent of the variance after 4 quarters. Foreign output shocks do not have any explanatory power for Iran's output growth. The other two domestic shocks (inflation and exchange rate) together account for 9 per cent of forecast error variance of output growth after 1 quarter.

These results show that without reducing the inherent volatility of output growth (by reforms and better management), it is unlikely that sanctions removal would enable the Iranian economy to return to single digit inflation and sustained growth.

## 6.3 Estimates of sanctions-induced output losses

So far we have focussed on the channels through which changes in the intensity of sanctions affect the Iranian economy and the time profile of their propagations. Here we consider possible output losses due to the direct and indirect effects of the sanctions. However, the output growth equation included in the SVAR model, and its estimates presented in Column (4) of Table 3, is not suitable for this purpose, since output growth is specified to contemporaneously depend on exchange rate and inflation, and therefore does not take account of output losses that could arise indirectly through these variables. Instead, we consider the reduced form output growth regressions set out in Equation (4), and focus on specifications with $s_{t-1}$ as the intervention variable. We favor this specification over the one that includes both $s_t$ and $s_{t-1}$, since "sanctions news" does not contain anticipatory effects, and one would not expect contemporaneous changes in $s_t$ to affect output growth, as time is required for the real economy to adjust to sanctions news.[31] The estimates of the reduced form output growth equations computed over the period 1989q1-2020q1 are summarized in Table S.9 in the online supplement, where we report both the short- and long-run effects of sanctions on output growth, whilst allowing for a host of both domestic and foreign control variables.[32] The parameter of interest is the long run effect of sanctions on output growth reported at the bottom panel of Table S.9. It is estimated to be around $-0.031$ $(0.013)$, which is statistically significant and remarkably robust across the seven different specifications reported.[33] This in turn suggests output growth losses of around 2 per cent per annum if we use the median value of $s_t$ over the sample under consideration, or 3 per cent if we use the mean value of $s_t$.[34] Due to the large outliers in the sanctions intensity variable, we favor the lower estimate of 2 per cent based on the median value of $s_t$, which in turn suggests that in the absence of sanctions and sanctions-induced mismanagement Iran's average annual growth over 1989q1–2020q1 could have been around $4-5$ per cent, as compared to the 3 per cent realized, a counterfactual outcome which is close to the growth of emerging economies such as Indonesia, South Korea, Thailand, and Turkey whose average annual growth rate over the same sample period amounted to 4.8, 4.5, 4.2 and 4.0 per cent, respectively.

# 7 Wider economic and socio-demographic effects of sanctions

In this section we consider the effects of sanctions on the sectoral composition of output, employment, labor force participation, education, and consider if sanctions tend to have a gender bias. For this purpose we shall be using annual data, as quarterly observations are not available for many indicators of interest.

[31] We are grateful to Nick Bloom for drawing our attention to this point.

[32] Amongst the domestic variables, only inflation has a statistically significant impact on output growth. But, once again, we find that global factors such as global volatility or output growth do not affect Iran's output growth, largely due to Iran's relative economic isolation. The only global factor which is statistically significant in the output growth equation is the exchange rate. The negative effect of inflation on output growth could be due to price distortions and allocation inefficiencies that are often associated with high and persistent levels of inflation, as has been the case in Iran. The negative effect of the global exchange rate variable on output growth is more difficult to rationalize.

[33] Similar estimates are obtained if both $s_t$ and $s_{t-1}$ are included in the regressions. See Table S.10 of the online supplement.

[34] The median and mean values of $s_t$, are 0.16 and 0.24, respectively, as summarized in Table 2.

## 7.1 Differential effects of sanctions on sectoral output growths

Since sanctions primarily affect oil revenues, foreign trade and international payments, they are likely to have differential sectoral effects with traded goods and financial sectors being more affected. In the case of Iran the least traded goods sector is agricultural and parts of the service sector. It is, therefore, plausible to expect sanctions to have less impact on the agricultural sector as compared to the manufacturing and service sectors. To investigate the sectoral effects of sanctions, we estimate VAR(1) models in sectoral growth rates with the results summarized in Table S.11 of the online supplement. As can be seen, output growths of manufacturing and service sectors are affected negatively by sanctions and these adverse effects are statistically highly significant. But the same can not be said about the output growth of the agriculture sector, which seems to be hardly affected by sanctions. It is also interesting that whilst there are significant inter-linkages between manufacturing and services, there are no significant feedbacks between agriculture and the rest of the economy. These findings are robust across the various specifications that allow for a large combination of control variables.

We also note that sanctions have affected the manufacturing sector much harder than their effects on the service sector. The median annual sanctions-induced fall in manufacturing growth is about 2.4 per cent, as compared to 1.2 per cent per for services. Even though industries such as banking and finance have been seriously hampered by sanctions, services might have suffered less than manufacturing as a result of the ongoing shift towards the knowledge-based economy under way in Iran.

In the online supplement we report additional results for the shares of each of these sectors out of the total value added. [35] Our main finding is that sanctions targeting Iran have caused the agricultural sector to become more important with respect to the overall economy, while the manufacturing sector shrinks. Conversely, the share of services out of the total is not significantly affected. Therefore, even though sanctions have somewhat slowed down the growth of services value added, the share of services out of the total value added has not declined in a statistically significant way as a result of that.

These findings seem to confirm that sanctions are reflected not only in lower output growth rates but also in a change of the sectoral composition. The sectors that are more trade-intensive shrink the most, while a greater reliance on agriculture and home-made innovations potentially comes into play.

[35] See Tables S.12 to S.14 of the online supplement.

## 7.2 Effect of sanctions on labor outcomes

It is reasonable to expect that sanctions-induced disruptions and economic slow downs have spill-over effects on the labor market, both in terms of employment and labor force participation. To this end we run regressions of a few labor market indicators on the sanctions intensity variable, with the results summarized in Tables S.15 to S.17 of the online supplement. We measure these indicators relative to the trends in other MENA countries to take account of common socio-economic factors of the region. We also include a number of additional control variables in the regressions to reduce possible confounding effects.

Table S.15 gives the regressions results for the rate of change of employment in Iran relative to other countries in the MENA region, and shows that Iran's employment rate contracts by about 1 per cent per year more than in other MENA countries as a reaction to sanctions. [36] No other control variables have statistically significant effects except some mild positive spill-overs from Turkey output growth, a feature that may relate to the interconnections between the two economies.[37]

More interestingly, we find statistically significant evidence of a gender bias. Sanctions, measured at their median value of 0.16, resulted in male labor force participation declining by 0.5 per cent per year – an impact that is statistically significant but economically small. See Table S.16 of the online supplement. However, female labor participation was much more affected by sanctions, with the coefficient of the sanctions variable being statistically highly significant and much larger as compared to the results for males. See Table S.17 of the online supplement. A median level rise in sanctions intensity has caused the rate of female labor force participation in Iran to fall by about 3.8 per cent relative to other MENA countries. To give a sense of the magnitude of such an effect, we notice that after the period of highest international pressure 2006–2014, female labor force participation rate declined by more than 30 per cent (from its peak of 19.5 per cent in 2005 to 13.4 per cent in 2014).

Overall, we confirm the economic intuition that links output declines to employment losses. The worsening of labor market conditions is sizeable and statistically significant. However, to the best of

[36] Recall that for assessing the effects of sanctions, we need to multiply all coefficients related to $s_t$, and $s_{t-1}$, by their median value of 0.16, given in Table 2 of the online supplement. In this way, we compare the effects of sanctions at their median values with the no sanctions $(s_t = 0)$ outcomes.

[37] Similar results are obtained when using total labor force participation. See Table S.18 of the online supplement.

our knowledge, our study is the first to provide quantitatively robust measures of gender bias in Iran resulting from sanctions. There are many economic as well as social factors behind this outcome. One plausible scenario points to resource allocation away from females at times of reduced oil revenues and budget cuts, with males given priority for jobs and wages over females.

### 7.3 Effect of sanctions on education outcomes

Finally, we ask if the education system has also been affected by sanctions. If economic sanctions impair the government's budget then we would expect to see some decline in expenditures on schools and teachers. We provide evidence for the effects of sanctions on the number of lower secondary schools and high schools in Tables S.19 and S.20 in the online supplement. For comparison we also provide similar results for the number of primary schools in Table S.21. These results clearly show that indeed lower secondary schools and high schools have been adversely affected by sanctions. But, interestingly enough, the number of primary schools does not seem to have been affected by sanctions, which could be due to the compulsory nature of primary education in Iran, that obligates the government to provide schools and teachers commensurate with the demographic rise in the number of students.[38]

To investigate whether the gender bias documented in the case of labor force participation is also present in the education sector, in Table S.22 of the online supplement we show regressions of the rate of change of female-to-male student ratio on the sanctions variable, as well as a number of control variables. We see that sanctions have depressed this ratio, an effect which is sizeable as well as being statistically highly significant. Data from 1989 onwards confirm a sanctions-induced reduction of about 0.5 per cent per annum on average.

## 8 Concluding remarks

In this paper, using a novel measure of the intensity of sanctions based on newspaper coverage, we have quantified the effects of sanctions on exchange rate, inflation, output growth, employment, labor force participation, and secondary and high school education in Iran. Our empirical analyses also show that sanctions, perhaps unintentionally, accentuate rather than reduce gender bias, and divert resources from

[38] The impact on the number of teachers is very similar to the one experienced by the number of schools. See Tables S.23, S.24 and S.25 in the online supplement.

education to other more pressing immediate needs such as maintaining consumption at the expense of physical and human investments.

There is no doubt that sanctions have harmed the Iranian economy, but one should not underestimate the damage done by years of economic mismanagement. Iran's low output growth relative to its potential, high inflation and excess output growth volatility cannot all be traced to sanctions and have domestic roots stemming from prolonged periods of economic mismanagement, distorted relative prices, rent seeking, a weak banking system and under-developed financial institutions. Sanctions have accentuated some of these trends and delayed the implementation of badly needed reforms.

A more comprehensive analysis of sanctions also requires detailed investigation into how sanctions and their variability over the past forty years have affected policy decisions at all levels, from monetary and fiscal policies to industrial, regional and social policies. It is generally agreed that, at times of increased sanctions intensity, governments fearful of political consequences are reluctant to curtail distortionary policies, such as large subsidies on food and energy, and they might even accentuate them, or resort to multiple exchange rates to reduce the inflationary effects of sanctions.

In evaluating the direct and indirect costs of sanctions, we have followed the literature and attempted to control for possible confounders, namely external and domestic factors that affect the economy but are unrelated to sanctions, such as advances in technology, world output growth, international prices, and economic performance of some neighboring economies. Using a reduced form regression of output growth on our sanctions intensity variable we estimate Iran's output loss to be around 2 per cent per annum, which is considerable when cumulated over time. There is, of course, a high degree of uncertainty associated with such estimates which should be born in mind. But even if we compare Iran's growth performance over the 1989q1-2021q1 period with that of Turkey and other similar size emerging economies we find that Iran's realized output growth of 3 percent still lies below the average growth of 4.4 per cent experienced by Indonesia, Turkey, South Korea and Thailand over the same period.

We also recognize the importance of investigating the possible effects of sanctions on price distortions and rising income inequality and poverty. Real expenditure of households in Iran has been falling; more in urban than in rural areas. The income gap is most pronounced between the top and the bottom deciles of expenditure distribution. The Gini coefficient, a measure of overall inequality, in Iran has been rising and is almost at the same level of the Gini coefficient of the U.S., which is amongst the highest in advanced economies. Another important area if the possible effects of sanction on price distortions, and their implications for productivity and employment. However, detailed studies of these important topics are beyond the scope of the present paper.

Sanctions have also led to some positive unintended effects. Non-oil exports have risen from $600 million before the Revolution to around $40 billion, resulting in greater foreign exchange diversification. The high-tech sector has seen exponential growth over the past 10 years and is now one of the regions' fastest growing sectors. Iran's major web-based companies have been protected by potential competition from their U.S. counterparts shown in brackets including: Digikala (Amazon), Aparat (YouTube), Cafe Bazaar (Google Play), Snapp (Uber), Divar (Craigslist). It is estimated that over 65 per cent of Iranian households are now connected to the internet. This rapid expansion was facilitated by the government and security apparatus making affordable high-speed internet a reality in Iran. The Mobile Telecommunication Company of Iran, largely controlled by the Islamic Revolutionary Guard Corps now has over 43 million subscribers. Sanctions have also resulted in significant advances in the areas of missiles and other military-related technologies. It is estimated that IRGC control between 10-30 per cent of the economy, with large stakes in the oil and gas sectors, construction, telecom, banking, and tourism. One could argue that IRGC has been a major beneficiary of U.S. sanctions.

Our analysis also clearly shows that sanctions can only explain a relatively small fraction of the variance of output growth, and the cause of Iran's low and excessively volatile output growth should be found elsewhere. This in turn suggests that lifting of sanctions will most likely have short-term positive effects and for long term sustainability major reforms are required, in addition to better management of the economy. This involves wide ranging reforms of banking, the tax and subsidy system, unification of exchange rates, and the development of a coherent system of social safety net to protect the poor. Regional development policies should be initiated by giving priority to remote regions that have been left behind. Government policies should become more transparent with greater openness to private sector initiatives and foreign investments. Insulating the economy against oil revenue volatility will also become an urgent policy issue once sanctions are removed. In the past, the Iranian economy has been very sensitive to oil price volatility and, over the longer term, Iran needs a sovereign wealth fund to smooth the impact of the volatility of oil revenues. The primary challenge is how to integrate the Iranian economy within the regional and global economic system, so that Iran's true economic potential can be realized.

Finally, it is important to bear in mind that Covid-19 could not have come at a worse time for the Iranian economy. Our sample does not cover the period from March 2020 when Covid-19 effects started to be felt in Iran. But it is clear Covid-19 could have important medium term consequences, particularly for the traditional service sector. The Covid shock has been truly global – it has hit almost 200 countries with different degrees of severity, with its effects magnified through global trade and financial linkages. The full economic impact of Covid-19 on the Iranian economy is unknown and requires further investigation.

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# Online supplement to "Identifying the Effects of Sanctions on the Iranian Economy using Newspaper Coverage"

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## S.1 Introduction

This online supplement is composed of four main sections. Section S.2 gives details of data sources and construction of some of the key variables used in our analysis. Sub-section S.2.1 provides details of how the proposed sanctions intensity variables are constructed. Sub-section S.2.2 gives information on conversion of data from the Iranian calender to the Gregorian calender. Sub-section S.2.3 provides details of data sources for the socio-economic variables. In Section S.3 we present details of the bootstrapping procedure used to compute error bands for the impulse response functions (IRFs). Section S.4 reports other empirical results such as the AR specifications for the world output growth, additional IRFs for a shock to the global output growth not presented in the paper, and further estimates on the impact of sanctions on the Iranian economy and its education system. Finally, a comprehensive list of all major sanctions against Iran from November 1979 to January 2021 is provided in Table S.28.

## S.2 Data appendix

### S.2.1 Sanctions intensity variables

Our sanctions intensity variable, $s_t$, is based on newspapers coverage of sanction events against Iran. Articles were retrieved from the platform *ProQuest* (www.proquest.com) which covers the whole period of interest 1979q1–2020q3. ProQuest has detailed newspapers archives with good search capabilities. The only exception to ProQuest was the *Financial Times Historical Archive* accessed through *Gale Historical Newspapers* (www.gale.com/intl/primary-sources/historical-newspapers), which helped to fill a gap left by ProQuest for articles published in the Financial Times before 1996.

#### Criteria of inclusion

We focused on six major newspapers: the New York Times, the Washington Post, the Los Angeles Times, the Wall Street Journal, the Guardian, and the Financial Times. We only selected articles published in the newspapers print version thus disregarding blogs, websites and other digital formats which are only available more recently; however, we did allow for all types of articles to be included, e.g. we included both editorials and main articles.

ProQuest has both a general *ProQuest Central* database, holding information for the relatively more recent publications, and several historical newspaper-specific collections for the most highly printed world outlets, *ProQuest Historical Newspapers*, which proved useful in order to extend our series back to 1979. Accordingly, we used the ProQuest Central data for the maximum period available for each newspaper, and complemented each series with the *ad-hoc* historical data sets before such dates. See Table S.1 for details. As mentioned already, the only exception was the articles published in the Financial Times before 1996, for which there does not exist a historical archive on ProQuest, and instead Gale Historical Newspapers were used.

To create the index of sanctions imposed on Iran ("sanctions on"), articles were required to include the following terms: "economic*", "sanction*", "against", "Iran*", with the additional feature of excluding articles in which "lift*" was present. The star at the end of the previous words allowed the search engine to pick words beginning with the same initial letters thus including terms such as: "sanctioning", "Iranian", "lifting" etc.. Although the number of potential synonyms and keywords to describe the phenomenon is virtually very high, this set of words seemed to capture rather well the extent to which Iran was mentioned as target of international measures. We also found that further complicating the search did not produce sensible results, as the new commands often could not be recognized by the search engine.

The search was carried out for each newspaper series separately by specifying the name of the newspaper in the options list "Publication title – PUB". For some newspapers the search engine produced a handful of duplicates of the same articles despite the option "Exclude duplicate documents" under "Result page options" had being ticked. To address this issue, all articles were manually checked before starting the download in order to avoid double-counting of articles.[1]

For the period 1990q3–1991q2, the search commands for sanctions against Iran were updated to exclude also the word "Iraq". This adjustment was necessary in order to avoid confounding noise due to the events of the Iraq invasion of Kuwait in August 1990, and the subsequent Gulf War period, from January to February 1991. These events received massive press coverage, which led Iran to be mentioned for geopolitical reasons, not because of sanctions. Also, some newspapers reported two additional small spikes not strictly related to Iran: (*i*) For the terrorist attacks happened between December 1985 (in Rome and Vienna airports) and April 1986 (in a West Berlin discotheque); (*ii*) For the "1998 Coimbatore bombings" attacks in southern India. In both cases, Iran was not the target of new sanctions therefore a manual check deletion of these small number of occurrences had to be carried out.

The intensity variable to capture the partial lifting of sanctions ("sanctions off") included the words beginning with "economic*", "sanction*", "against", "Iran*" but now allowing also for *at least* one of the

[1] The extent of this technical hurdle varied considerably amongst outlets. It was particularly severe for journals such as the Los Angeles Times, while virtually non-existent for other newspapers such as the New York Times.

following words: "lift*", "waive*" and "accord*". An exception was made for the Historical Database of the Financial Times, which does not support sophisticated search structures. Therefore, a simple research allowing for "sanctions against Iran" and "deal*" was conducted to capture the highest number of articles, which were subsequently checked and skimmed manually to meet our criteria of inclusion.

A detailed chronological study of economic sanctions against Iran allowed us to restrict our search of "sanctions off" on two time periods only. First, in 1981 when the Algiers Accords were signed and the "Tehran hostage crisis" ended; second, from 2016q1 to 2018q2, when the Joint Comprehensive Plan of Action (*JCPOA*) was enacted by all world major powers before U.S. President Trump withdrew the country from the agreement. Accordingly, for construction of the sanction-off index we focussed on the periods 1981q1–1981q4 and 2015q1–2018q2 in order to avoid unnecessary noise for the time in between and after Trump's announcement. The "sanctions off" period of our indicator was extended to one year before the actual implementation of the JCPOA in order to allow for possible anticipatory effects.

**Sanctions intensity variable construction**

Having obtained a number of daily articles related to the sanctions imposed ("sanctions on") and lifted ("sanctions off"), we proceeded with the following steps in order to build our estimator, $s_t(w) = s_{t,on} - w \times s_{t,off}$. Here we focus on the construction of $s_{t,on}$. The same procedure was used to construct $s_{t,off}$.

First, we computed a monthly series for each of our $J$ newspapers ($J = 6$) by averaging our daily series over the number of articles per month. In turn, we carried out a simple average across newspapers, which led us to have a single monthly series of "sanctions on" articles; subsequently, we averaged the monthly observations over each quarter to obtain the quarterly series. The "sanctions on" average was then divided by its maximum value over the period 1989q1–2020q3 in order to obtain the indicator $s_{t,on}$; so that $s_{t,on}$ index was defined on the $(0,1)$ range. We obtained a second variable $s_{t,off}$ from our "sanctions off" raw count by following the same steps just described. Finally, we estimated the weight, $w \in (0,1)$, with a grid search in order to derive our final sanctions intensity variable $s_t = s_{t,on} - w \times s_{t,off}$. The grid search was performed by running the regressions:

$$\Delta y_t = \beta_0 + \beta_1 \Delta y_{t-1} + \beta_2 s_{t-1}(w) + \varepsilon_t,$$

over the period 1989q1–2020q1, with $\Delta y_t$ being Iran's quarterly real output growth, and with a step size of our grid equal to 0.1. The optimal weight was estimated as $\hat{w} = 0.4$, although the shape of the likelihood was rather flat.[2]

As a robustness check, we created a standardized version of our indicator by following the approach advanced by Baker et al. (2016). We divided each of the $J$ newspapers monthly *raw* series by their respective standard deviations. [3] The final standardized intensity variable was obtained as before by averaging across newspapers at monthly frequency, taking the simple mean for each quarter (for both

[2] The *annual* series for $s_t$ was computed as a simple average of the quarterly intensity variable over each year.

[3] For a measure of "sanctions on", we considered the standard deviations over the entire period 1979m1–2020m9. For "sanctions off", the monthly raw counts during 1981m1–1981m12 and 2015m1–2018m6 were divided by the standard deviations over their respective periods.

Table S.1: Sources of newspaper articles over the period 1979m1–2020m9

| | Period | |
|---|---|---|
| | Historical dataset | Modern dataset |
| New York Times | 1979m1–1980m12 | 1981m1–2020m9 |
| Los Angeles Times | 1979m1–1984m12 | 1985m1–2020m9 |
| Washington Post | 1979m1–2002m12 | 2003m1–2020m9 |
| Wall Street Journal | 1979m1–1983m12 | 1984m1–2020m9 |
| Guardian | 1979m1–1996m12 | 1997m1–2020m9 |
| Financial Times | 1979m1–1995m12 | 1996m1–2020m9 |

**Notes**: "Historical data set" is the *ProQuest Historical Newspapers* data set for all newspapers except the Financial Times, for which information have been retrieved from *Gale Historical Newspapers.* "Modern data set" is *ProQuest Central* database for all newspapers considered.

sanctions "on" and "off"), dividing each series by their respective maxima over the period 1989q1–2020q3, and subtracting the "standardized sanctions off" series from the "standardized sanctions on". We found these weighted sanction on and sanction off series to be very close to the ones based on simple averages, and as a result the grid search applied to the weighted series also resulted in the estimate $\hat{w} = 0.4$. Even though this procedure was meant to avoid newspapers with a larger number of articles per issue to carry unwarranted weight, the two series co-move almost perfectly $(\rho = 0.998)$. See Figure S.1. This finding is consistent with Plante (2019), who adjusts for the number of total articles per month and finds that his two measures correlate at 0.97.

**U.S. Treasury sanctions variable construction**

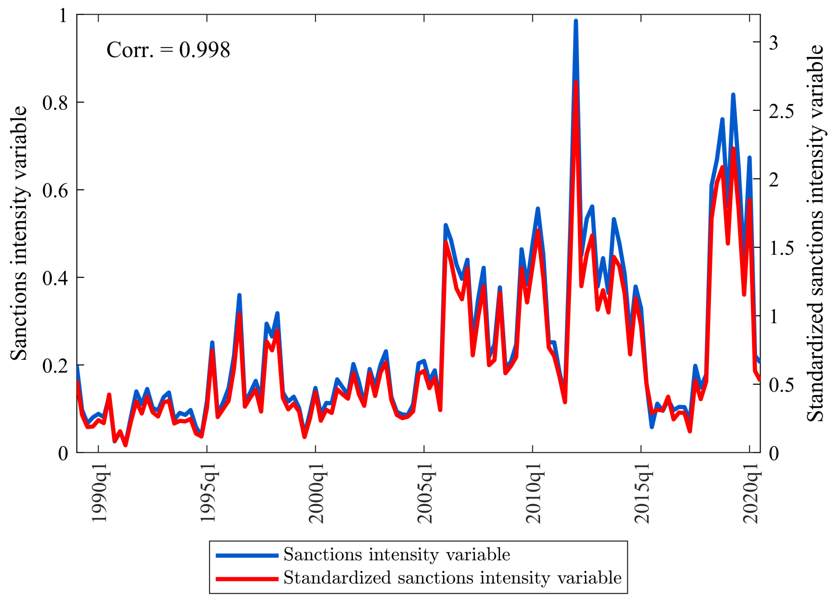
We also constructed a measure of sanctions intensity based on the U.S. Treasury "Specially Designated Nationals And Blocked Persons List (*SDN*)". The online database of the Treasury keeps track only of the entities *currently* sanctioned. To compile a complete time series list of all Iranian entities, individuals, and vessels being sanctioned by the U.S., we used yearly *pdf* files available in the online archive of the U.S. Treasury. In this way, we were able to follow over time each entity entering and exiting the database.[4] The list of sanctioned entities can be retrieved from 1994 onwards but the number of entries for Iran up to 2005 is negligible. This is in line with the historical record of U.S. sanctions against Iran. Therefore, we focussed on building our entry-exit matrix from 2006 onwards.

To construct the *U.S. Treasury sanctions variable*, we first summed the total number of Iranian entities, individuals, and vessels being hit by U.S. sanctions.[5] In the SDN lists, entities refer to companies (and institutions) of Iranian nationality, foreign companies having offices in Iran, and – in light of secondary sanctions – all other foreign companies doing business with sanctioned Iranian compa-

[4] The documents specify the exact day in which entities enter/exit the list during the year considered.

[5] Notice that SDN lists specify to which sanctions programs each entry belongs. In other words, according to whether the aim is to hit entities related to Iran vis-à-vis other nations (say, North Korea) different codes are attached to them.

Figure S.1: Sanctions intensity variable and standardized sanctions intensity variable over the period 1989q1–2020q3



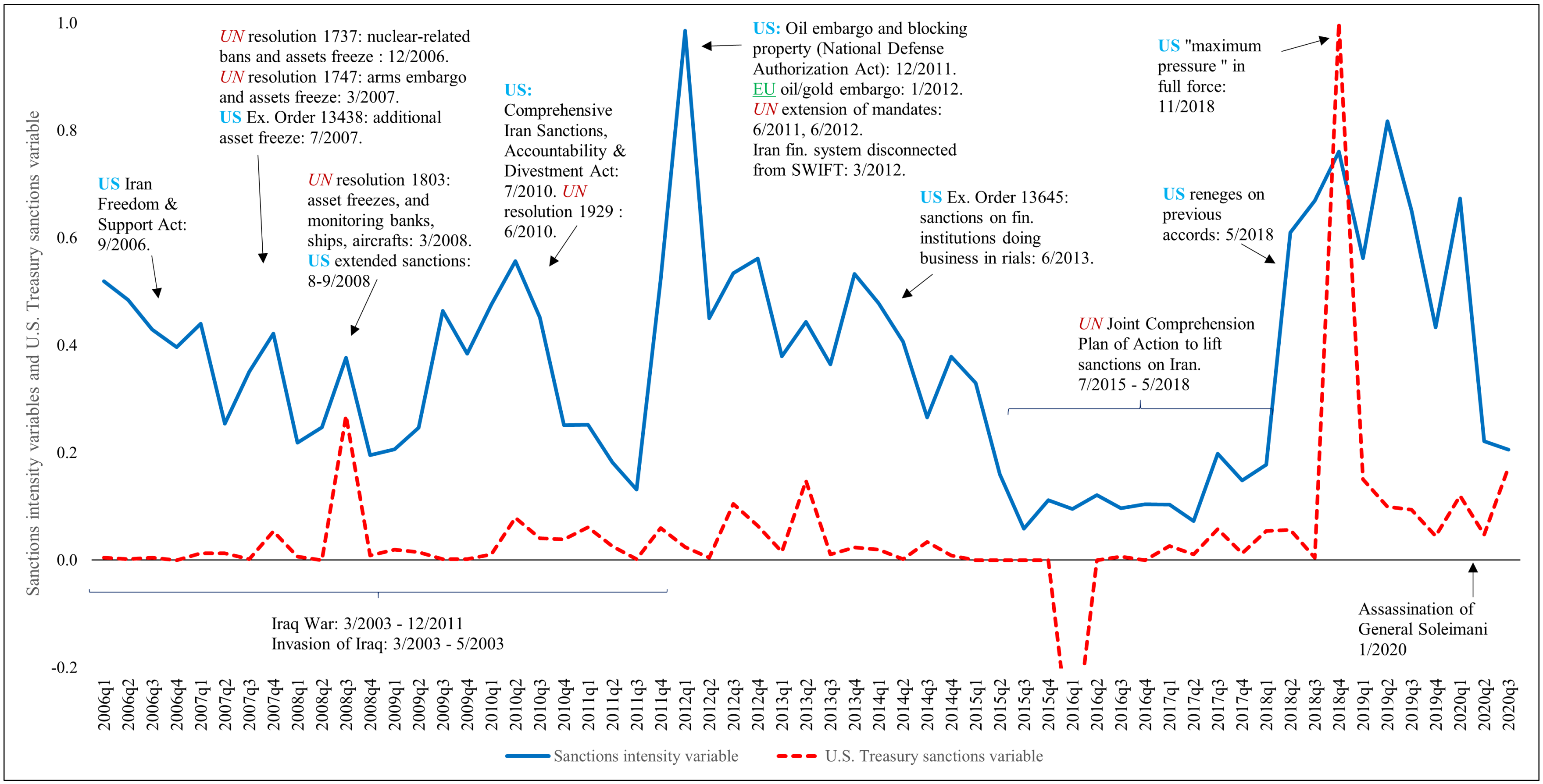

**Notes**: See Section 5 of the paper for the sanctions intensity variable definition over the range (0,1). See Section S.2.1 in the data appendix of the online supplement for details on construction of both the sanctions intensity variables.

nies. Iranian individuals, or foreigners doing business with sanctioned Iranians, were tracked by First and Last Name, and Passport number or National ID – when available. For vessels, we did not confine ourselves to vessels name or national flag given that these attributes were often changed. Instead, the International Maritime Organization (*IMO*) unique identification number proved to be important and completely reliable to follow vessels history.

The number of Iranian entries added to the SDN list allowed us to build an "SDN sanctions on" time series; similarly, the entries removed from the list provided the information for an "SDN sanctions off" index. We obtained our final "U.S. Treasury sanctions variable" by attaching a weight to the "SDN sanctions off" count equal to the newspaper-based indicator ($w = 0.4$) and subtracting it from the "SDN sanctions on" count. The final series was then re-scaled by dividing it for its maximum value. See Figure S.2. The correlation between the U.S. Treasury measure and $s_t$ is equal to 38 per cent over the period 2006q1–2020q3. Notice that the series based on SDN has inevitably negative values over the JCPOA period regardless of the weight one is willing to choose. This feature is due to the fact that no new Iranian entities were added, while a large number of previously sanctioned entities were removed.[6]

[6] This could also be considered as a shortcoming of using such measure given that – in our framework – a negative value of the sanctions intensity variable means an attempt to subsidize the Iranian economy through transfers, something far from the actual process happening over the period 2016q1–2018q2.

Figure S.2: Sanctions intensity variable and the U.S. Treasury sanctions variable over the period 2006q1–2020q3




**Notes**: The U.S. Treasury sanctions variable is computed from the number of newly introduced and removed entries in the "Specially Designated Nationals And Blocked Persons List" (*SDN*) of the U.S. Department of the Treasury. Major sanctions-related historical events are indicated by arrows and brackets. See Section S.2.1 for details of the construction of the sanctions variables.

### S.2.2 Conversions from Iranian to Gregorian calendar

The data we use in our analysis are in Gregorian calendar. However, data retrieved from Iranian sources, namely from the Central Bank of Iran and the Statistical Center of Iran, follow the Iranian calendar format. The Iranian year starts on March $21^{st}$ of the corresponding Gregorian year. Accordingly, we carried out three calendar conversions in order for the Iranian data to be in line with the ones in the Gregorian format. In the following expressions, $G_y, G_q$, and $G_m$ stand for the variables transformed in the Gregorian calendar at yearly, quarterly, and monthly frequencies, respectively, while $I_y, I_q$, and $I_m$ are the data in the original Iranian format. For annual statistics, the following formula was applied: [7] $G_y = \frac{80}{365} I_{y-1} + \frac{285}{365} I_y$. For quarterly data, we converted the Iranian series according to:[8] $G_q = \frac{8}{9} I_{q-1} + \frac{1}{9} I_q$. Finally, for the monthly time series – we applied the following transformation: $G_m = \frac{1}{3} I_{m-1} + \frac{2}{3} I_m$.

### S.2.3 Economic and socio-demographic variables

In this section, we will refer to some of the Iranian data as being retrieved from the "Quarterly Iran Data Set 2020". In this case, we extend and update the data for Iran in the GVAR Data Set compiled by Mohaddes and Raissi (2020) until 2018q2 (and available upon request); more recent observations for Iran were added by splicing forward the previously available series with new observations from Iranian sources. In this respect, the conversions mentioned in Section S.2.2 were applied. All data from the Central Bank of Iran (*CBI*) were obtained from the *Economic Time Series Database*. For global factors we will refer to the "GVAR Data Set 2020". In this case, we use the latest version of the GVAR Data Set provided by Mohaddes and Raissi (2020), which we extend to include observations for 2020q1.[9]

**Quarterly data**

The quarterly real output of Iran was obtained by splicing forward the GVAR series in the Quarterly Iran Data Set 2020 available until 2018q2 with the "Iran's Quarterly National Accounts" released by the Statistical Center of Iran until 2020q1.

Iran's inflation was computed as first difference of the natural logarithm of Iran consumer price index (*CPI*). CPI data from the GVAR series in the Quarterly Iran Data Set 2020 available until 2018q2 were extended forward with data from the Statistical Center of Iran, which provides Iranian monthly inflation bulletins. After having converted the monthly series to the Gregorian calendar, it was possible to compute the quarterly inflation rate, and splice forward the Quarterly Iran Data Set until 2021q1. The CPI was then rebased to have value equal to 100 in 1979q2.

The *official* foreign exchange statistics from 1979q2 to 2020q3 were retrieved in quarterly format from Bank Markazi (Iran's Central Bank), and converted to the Gregorian calendar. The *free market* foreign exchange rate in quarterly format from 1979q2 to 2017q4 was also retrieved from Bank Markazi. For 2018 onward the series were spliced forward with data from *bonbast.com* – a highly cited website

[7] Eighty days of the Gregorian year (from Jan. $1^{st}$ to Mar. $21^{st}$) were to be attributed to the previous Iranian year.

[8] In the following expression, $8/9$ represents the eighty days out of the approximately ninety days within a given quarter.

[9] Mohaddes and Raissi (2020) data set ends in 2019q4. The extended data set is available upon request.

tracking the Iran's rial free market rate against all major currencies. In this regard, *bonbast.com* presents information for "buy" and "sell" rates at daily frequency. We used the average of buy and sell rates. In this way we were able to extend the historical series from Bank Markazi until 2021q1.

Monetary statistics were also downloaded from the Bank Markazi website. The monetary aggregate $M2$ was computed as the sum of $M1$ and "quasi-money". Data were available at quarterly frequency, and – before converting them to the Gregorian calendar – the observations from 2015q2 onwards had to be multiplied by 1,000 given a change of format from billions to trillions of rials.

In order to account for global factors, we augmented our analyses with several variables. $\Delta p_t^0$ is the rate of change of the oil price (first difference of the natural logarithm). The oil price considered was the Brent crude (U.S. dollars/barrel). Data at quarterly frequency until 2020q1 were taken from the GVAR Data Set 2020. Observations for 2020q2 and 2020q3 were obtained by splicing the series with data from the U.S. Energy Information Administration (series name: "Europe Brent Spot Price FOB, Dollars per Barrel"). The E.I.A. provided information at monthly frequency therefore we first averaged the oil prices over each quarter, and then spliced forward our GVAR time series.

The quarterly global realized volatility, $grv_t$, was taken directly from the GVAR Data Set 2020 for the whole period 1979q2–2020q1; details about its construction can be found in Chudik et al. (2020).

We used the GVAR Data Set 2020 and followed the procedure indicated by Chudik et al. (2020) also for the construction of the other global factors. The factors we considered are: the world real output growth, $\Delta\bar{y}_{wt}$; the rate of change of the world real exchange rate against the U.S. dollar, $\Delta\bar{e}_{wt}$; the world real equity returns, $\Delta\overline{req}_{wt}$; and the per cent change of the world nominal long-term interest rate, $\Delta\bar{r}_{wt}$. These control variables were obtained by taking the first difference of the following weighted cross-sectional averages: $\bar{y}_{wt} = \sum_{i=0}^{n} w_i y_{it}$, $\bar{e}_{wt} = \sum_{i=0}^{n} w_i e_{it}$, $\overline{req}_{wt} = \sum_{i=0}^{n} w_i eq_{it}$, $\bar{r}_{wt} = \sum_{i=0}^{n} w_i r_{it}$, where $y_{it}, e_{it}$, $eq_{it}, r_{it}$ are: the log of real output, the log of the real exchange rate against the U.S. dollar, the log of real equity prices, and the nominal long term interest rates of country $i$ in quarter $t$. The sample included 33 of the world major economies, and the weights, $w_i$, were computed as the GDP-PPP average by country $i$ out of the overall world average output over the period 2014–2016:

$$w_i = \frac{\sum_{t=2014}^{2016} Y_{it}^{PPP}}{\sum_{i=0}^{n} \sum_{t=2014}^{2016} Y_{it}^{PPP}}. \tag{S.1}$$

The GDP-PPP measure allows for international comparisons, and it was retrieved at yearly frequency from the *World Bank Open Data* repository. The 33 countries are: Argentina, Australia, Austria, Belgium, Brazil, Canada, China, Chile, Finland, France, Germany, India, Indonesia, Italy, Japan, South Korea, Malaysia, Mexico, the Netherlands, Norway, New Zealand, Peru, the Philippines, South Africa, Saudi Arabia, Singapore, Spain, Sweden, Switzerland, Thailand, Turkey, the U.K., and the U.S.A..

For some of the 33 countries, real equities returns, $eq_{it}$, and nominal long term interest rates, $r_{it}$, were not available. As such, to compute $\overline{req}_{wt}$ and $\bar{r}_{wt}$ we focussed on the countries for which we had information, and rescaled the weights accordingly. In particular, the historical real equity prices, $eq_{it}$, were available for 26 out of 33 countries (excluded were Brazil, China, Indonesia, Mexico, Peru, Saudi Arabia, and Turkey). For the long run interest rates, $r_{it}$, data were available for 18 of the 33 countries (excluded were Argentina, Brazil, China, Chile, Finland, India, Indonesia, Malaysia, Mexico, Peru, the Philippines, Saudi Arabia, Singapore, Thailand, and Turkey).

We also considered real output growth for oil exporters, $\Delta\bar{y}_t^0$, and Turkey's output growth, $\Delta y_t^{Tur}$. The real output for oil exporters is the cross-sectional weighted average $\bar{y}_t^0 = \sum_{i=0}^{n_{oil}} w_i^0 y_{it}^0$, with the countries composing $n_{oil}$ being: Brazil, Canada, Mexico, Norway, and Saudi Arabia. The weights, $\left\{w_i^0\right\}_{i=1}^{n_{oil}}$, were computed following the same procedure described in Equation (S.1) but restricting the sample from $n$ to $n_{oil}$. Turkey real output growth is $\Delta y_t^{Tur} = \ln(Y_t^{Tur}/Y_{t-1}^{Tur})$, with $Y_t^{Tur}$ being Turkey real output in quarter $t$. The output series were retrieved from the GVAR Data Set 2020.

We also retrieved information on the U.S. CPI from the OECD accessed through the Federal Reserve Bank of St. Louis (*FRED*) data set. Table S.2 provides an overview of the data sources.

**Annual data**

*Economic variables* – We cumulated quarterly series, whenever available, to obtain annual series, such as Iran real output, $Y_t$; Iran consumer price index, $P_t$; Brent crude oil price, $P_t^0$; world, oil exporters, and Turkey real output data $\{\bar{y}_{wt}, \bar{y}_t^0, y_t^{Tur}\}$; and the global factors $\{\bar{e}_{wt}, \overline{req}_{wt}, \bar{r}_{wt}, grv_t\}$.

Data on value added by sectors (agriculture, manufacturing and mining, and services) were retrieved at annual frequency from the Bank Markazi. The series at constant 2004 prices was spliced forward in 2010 with the series at constant 2011 prices. Before splicing, each data series was converted to the Gregorian calendar format. For sectoral composition analyses: agriculture, manufacturing, and services shares of value added were computed as a fraction of the total value added represented by the sum of the three components.

Total exports and imports revenues in millions of dollars were retrieved from the Bank Markazi at annual frequency, and converted to the Gregorian calendar format. Oil and gas exports revenues, and non-oil exports revenues (in millions of U.S. dollars) were also obtained from Bank Markazi website. However, it is important to bear in mind that for both oil and gas, and non-oil exports, Bank Markazi holds two data sets based on the "fourth edition" and "fifth edition" directives of the annual IMF Balance of Payment statistics.[10] We followed the fourth edition, which was available for almost the whole of the period under consideration (until 2018), and obtained data for 2019 by splicing forward the series with information from the fifth edition.[11]

The historical data series on annual oil exports in thousands of barrels per day was also compiled from the Bank Markazi. But this series ended in 2018 therefore – after having converted it to the

[10] Under the fourth edition oil exports category was defined as "Crude oil, oil products, liquefied gas and natural gas". In the fifth edition, the description is: "Value of crude oil, oil products, natural gas, natural gas condensate and liquids (Tariff codes: 2709, 2710 and 2711) exported by National Iranian Oil Company (NIOC), National Iranian Gas Company (NIGC), National Iranian Oil Refining and Distribution Company (NIORDC), petrochemical companies, and others (customs and non-customs)". Tariff codes refer to unique identifying numbers adopted by the UN Statistics Division.

[11] The correlation of oil and non-oil exports growth under the two systems of reference was 99.5 per cent and 92.8 per cent, respectively, for the overlapping period 1997–2018 for which we had data for both series.

Gregorian calendar – we spliced it forward with IMF data "Crude Oil Exports for Iran" series for the years 2019 and 2020, which we retrieved from FRED.

*Education variables* – Bank Markazi "Economic Time Series Database" allows to retrieve further statistics on education such as the number of schools (from 1979 to 2018), and the number of teachers (from 1979 to 2019). In each case, it was possible to obtain data on the number of schools and teachers both at aggregate level and divided by grade: primary, lower secondary, and high school. Furthermore, we retrieved data on the overall number of students by gender. Information on the number of students by gender for each school grade was discontinued in 2013. The total number of schools was computed as the sum of primary, lower secondary, and high schools. When using the series on the number of teacher employed, we always divided it by the yearly Iran population in the 25–64 age group, in order to control for population increases.

The "Female-to-male students enrollment ratio", $\Delta fm_t$, is the log difference of the ratio between female and male students. Female and male enrolled students were divided by the female and male population in the 5–19 age groups, respectively, to account for general population increases by gender. Specifically, $\Delta fm_t = \ln(FM_t/FM_{t-1})$, with $FM_t = (S_{ft}/Pop_{ft})/(S_{mt}/Pop_{mt})$ where $S_{ft}$ and $S_{mt}$ are the number of female and male students, respectively, and $Pop_{ft}$ and $Pop_{mt}$ are Iran female and male population in the 5–19 age group.

*Other socio-demographic variables* – Several other yearly socio-economic statistics were obtained from the "World Development Indicators" of the World Bank. More specifically, the male and female labor force participation rate,[12] the employment rate, total national population for a number of world economies (listed below), and Iran male and female population in the age brackets 5–9, 10–14, 15–19, 20–24, 15–64, as fraction of total Iran's male and female population. The absolute values for the population by sex and age bracket were computed by multiplying each fraction by the total number of males and females in Iran each year, while the population in the 25–64 age group was obtained by subtracting the population in the 15–24 age groups from the ones in the 15–64 age groups (which was available). The information about age brackets was used as demographic control when estimating the rate of change in the number of students enrolled in schools by gender. Similarly, the 25-64 population was used as a demographic control for the number of teachers employed in Iran.

We also constructed geographic regional aggregates for labor statistics, in particular for Middle East and North Africa (*MENA*). Each aggregate annual labor series, say $\bar{x}_{wt}$, was built as a weighted average of countries data series, $x_{it}$, i.e. $\bar{x}_{it} = \sum_{i=0}^{n} \widetilde{w}_i x_{it}$. Weights, $\widetilde{w}_i$, were based on the country annual population average out of the total population for the specific regional aggregate considered over the period 2014–

[12] The overall labor force for both Iran and MENA countries was computed by summing the male and female labor force participation rates.

2018:

$$\widetilde{w}_i = \frac{\sum_{t=2014}^{2018} Pop_{it}}{\sum_{i=0}^{n} \sum_{t=2014}^{2018} Pop_{it}}.$$

The MENA region in our statistics includes the following 17 countries: Bahrain, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syrian Arab Republic, United Arab Emirates, Yemen, Algeria, Egypt, Libya, Morocco, and Tunisia.

Table S.2: Sources of quarterly data

| **Data series** | **Source** |
|---|---|
| *Iranian variables*[1] | |
| Consumer price index | Quarterly Iran Data Set 2020 |
| Foreign exchange rate, Free Market | Central Bank of Iran and *bonbast.com* |
| Foreign exchange rate, Official rate | Central Bank of Iran |
| Money supply: M1 and Quasi-money | Central Bank of Iran |
| Real output | Quarterly Iran Data Set 2020 |
| *Global and regional control variables*[2] | GVAR Data Set 2020 and World Bank |

**Notes**: *1.* The Quarterly Iran Data Set 2020 extends and updates the GVAR Data Set compiled by Mohaddes and Raissi (2020), whose observations for Iran are available up to 2018q2. Such version of the data base including Iran is available upon request. The most recent observations for the consumer price index taken from the Statistical Center of Iran can be retrieved from the monthly inflation bulletins available at *www.amar.org.ir.* The data provided by the Central Bank of Iran on foreign exchange rates are available from the Economic Time Series Database: *tsd.cbi.ir,* under "External Sector/Value of Financial Assets (Exchange Rate and Coin Price)". Recent data on free market foreign exchange data can be retrieved from *www.bonbast.com*. Money supply statistics are available under "Monetary and Credit Aggregates" at *tsd.cbi.ir.* The data used to extend the Iran's real output series are taken from the Statistical Center of Iran and can be retrieved under "Iran's Quarterly National Accounts (base year = 1390)" from *www.amar.org.ir.*
*2.* Raw data for each country composing the global and regional averages were retrieved from the GVAR Data Set compiled by Mohaddes and Raissi (2020) and available at *www.mohaddes.org/gvar*. We extended the original data set from 2019q4 to 2020q1 – data are available upon request. The World Bank data (*data.worldbank.org*) have been used to construct the GDP-PPP weights for each country (code indicator: "NY.GDP.MKTP.PP.CD"). The variables included in this set of controls are: global nominal long term interest rate, global real equity price, global real exchange rate, global real output, global realized volatility, oil exporters real output, oil price (Brent crude), and Turkey real output. For oil price, the observations for 2020q2 and 2020q3 were obtained from the U.S. Energy Information Administration (series name: "Europe Brent Spot Price FOB, Dollars per Barrel") available at *www.eia.gov*. Information on the U.S. consumer price index was retrieved from the FRED data base *fred.stlouisfed.org* (series name: "Consumer Price Index: Total All Items for the United States, Index 2015=100, Quarterly, Seasonally Adjusted").
See Section S.2 for further details on variables construction.

Table S.3: Sources of annual data

| **Data series** | **Source** |
|---|---|
| *Iranian variables* | |
| Consumer price index | Quarterly Iran Data Set 2020 |
| Crude oil exports (th. barrels/day)[1] | Central Bank of Iran and IMF |
| Education statistics: Schools, students by gender, teachers[1] | Central Bank of Iran |
| Exports revenues (non-oil, oil & gas, and total)[1] | Central Bank of Iran |
| Foreign exchange rate, Free Market | Central Bank of Iran and bonbast.com |
| Foreign exchange rate, Official rate | Central Bank of Iran |
| Import revenues[1] | Central Bank of Iran |
| Labor statistics: Employment rate, Labor force participation rates[2] | World Bank, World Development Indicators |
| Money supply: M1 and Quasi-money | Central Bank of Iran |
| Population statistics[2] | World Bank, World Development Indicators |
| Real output | Quarterly Iran Data Set 2020 |
| Value added by sector[1] | Central Bank of Iran |
| *Global and regional control variables* | GVAR Data Set 2020 and World Bank |

**Notes**: *1.* Crude oil exports (th. barrels/day) data from the Central Bank of Iran are available from the Economic Time Series Database: *tsd.cbi.ir* under "Energy Sector" statistics. The observations from the IMF were retrieved through the FRED data base of the Federal Reserve Bank of St. Louis: *fred.stlouisfed.org* (series name: "Crude Oil Exports for Iran"). Data on education were retrieved from "Human resource and Employment" statistics available on the Central Bank of Iran repository *tsd.cbi.ir.* Export and import revenues are available from the same website under "External Sector/Balance of Payments (Manual)" statistics. Value added data are also taken from the same source under "National Accounts (1383=100)" and "National Accounts (1390=100)" statistics.
*2.* Labor and national population statistics are from the World Development Indicators of the World Bank for both Iran and other MENA countries accessed through *data.worldbank.org.* Employment rate (ages 15+, total) indicator code: "SL.EMP.TOTL.SP.ZS". Female labor force participation rate (per cent of female population ages 15+) indicator code: "SL.TLF.CACT.FE.ZS". Male labor force participation rate (per cent of male population ages 15+) indicator code: "SL.TLF.CACT.MA.ZS". National total population statistics indicator code: "SP.POP.TOTL".
See notes in Table S.2 for details on the sources of the other variables. See Section S.2 for further details on variables construction.

# S.3 Computation of IRFs, FEVDs and their error bands by bootstrap

## S.3.1 IRFs and FEVDs alternative computation

To compute the IRFs and FEVDs, we provide an alternative computation approach with respect to the one described in the paper. We confirm that we obtained the same numerical results as when we used the formulae in the paper, which we had included for pedagogic reasons.

Re-write Equation (S.2) as:

$$\widetilde{\mathbf{z}}_t = \widetilde{\Psi}_0^{-1}\left(\widetilde{\mathbf{a}}+\widetilde{\Psi}_1\widetilde{\mathbf{z}}_{t-1}+\widetilde{\Psi}_2\widetilde{\mathbf{z}}_{t-2}+\widetilde{\mathbf{u}}_t\right),$$

with $\widetilde{\mathbf{z}}_t = \left(\Delta e_{ft}, \Delta p_t, \Delta y_t, s_t, \Delta \bar{y}_{wt}\right)'$, and $\widetilde{\mathbf{u}}_t = (\varepsilon_{\Delta e_{ft}}, \varepsilon_{\Delta p_t}, \varepsilon_{\Delta y_t}, \varepsilon_{s_t}, \varepsilon_{\Delta \bar{y}_{wt}})'$. The IRF can be computed by following the approach described in the paper as:

$$IRF_{\mathbf{z}}(h) = \sqrt{\sigma_{jj}}(\mathbf{F}_h \widetilde{\Psi}_0^{-1} \mathbf{e}_j),$$

where $\mathbf{e}_j$ is a $(m+2) \times 1$ selection vector of zeros except for its $j^{th}$ element, which is unity, and

$$\mathbf{F}_\ell = \widetilde{\Phi}_1 \mathbf{F}_{\ell-1} + \widetilde{\Phi}_2 \mathbf{F}_{\ell-2}, \text{ for } \ell = 1, 2, \ldots$$

where $\widetilde{\Phi}_1 = \widetilde{\Psi}_0^{-1} \widetilde{\Psi}_1$, $\widetilde{\Phi}_2 = \widetilde{\Psi}_0^{-1} \widetilde{\Psi}_2$, with $\mathbf{F}_{-1} = \mathbf{0}$, and $\mathbf{F}_0 = \mathbf{I}_{m+2}$. Consequently, the impulse response effects of a positive one standard error change in the $j^{th}$ domestic shock, $\varepsilon_{jt}$, on the $i^{th}$ variable (the $i^{th}$ element of $\widetilde{\mathbf{z}}_t$) are given by:

$$IRF_{ij}(h) = \sqrt{\sigma_{jj}}(\mathbf{e}_i' \mathbf{F}_h \widetilde{\Psi}_0^{-1} \mathbf{e}_j), \text{ for } h = 0, 1, ..., H, \; i, j = \Delta e_{ft}, \Delta p_t, \Delta y_t, s_t, \Delta \bar{y}_{wt} \; .$$

The forecast errors can be now written more succinctly as:

$$\widetilde{\xi}_t(n) = \sum_{\ell=0}^{n} \mathbf{F}_\ell \widetilde{\Psi}_0^{-1} \widetilde{\mathbf{u}}_{t+n-\ell},$$

where, as before, $\widetilde{\mathbf{u}}_t$ is a vector of $(m+2) \times 1$ shocks. Similarly, the proportion of the forecast error variance of the $i^{th}$ variable due to a shock to the $j^{th}$ variable at horizon $h$ is given by:

$$\theta_{ij}(h) = \frac{\sigma_{jj} \sum_{\ell=0}^{h} \left(\mathbf{e}_i' \mathbf{F}_\ell \widetilde{\Psi}_0^{-1} \mathbf{e}_j\right)^2}{\sum_{\ell=0}^{h} \mathbf{e}_i' \mathbf{F}_\ell \widetilde{\Psi}_0^{-1} \Sigma \widetilde{\Psi}_0^{\prime -1} \mathbf{F}_\ell' \mathbf{e}_i}, \text{ for } i, j = \Delta e_{ft}, \Delta p_t, \Delta y_t, s_t, \Delta \bar{y}_{wt} \; ,$$

with $\Sigma = Diag(\sigma_{\Delta e \Delta e}, \sigma_{\Delta p \Delta p}, ..., \sigma_{\Delta \bar{y} \Delta \bar{y}})$. It can be proved that $\sum_{j=1}^{m} \theta_{ij}(h) + \theta_{is}(h) + \theta_{i \Delta \bar{y}_w}(h) = 1$.

### S.3.2 Bootstrapping procedure

In order to compute the impulse response functions (IRFs) and the associated confidence bands, we followed a bootstrap procedure by simulating the in-sample values of $\mathbf{z}_t$ in Equation (8), which we report here for convenience:

$$\Psi_0 \mathbf{z}_t = \mathbf{a} + \Psi_1 \mathbf{z}_{t-1} + \Psi_2 \mathbf{z}_{t-2} + \mathbf{u}_t. \tag{S.2}$$

In Equation (S.2), $\mathbf{z}_t = (\mathbf{q}_t, s_t, \bar{\mathbf{z}}_{wt})'$ is a vector of $m$ domestic policy variables ($\mathbf{q}_t$), the sanctions intensity variable ($s_t$), and the $k$ global factors ($\bar{\mathbf{z}}_{wt}$); $\mathbf{a}$ is a $(m+k+1) \times 1$ vector of constants, and $\mathbf{u}_t$ are the residuals of the system. In order to generate our bootstrap replications, we proceed as follows:

1. Generate the simulated residuals $\left\{\mathbf{u}_t^{(r)}, \; r = 1, 2, ..., R\right\}$ by resampling with replacement from the estimated residuals of each equation separately $\{\widehat{\mathbf{u}}_t, t = 3, 4, ..., T\}$, where $R = 1,000$ is the number of random samples.

2. Let $\mathbf{z}_{1989q1}^{(r)} = \mathbf{z}_{1989q1}$, $\mathbf{z}_{1989q2}^{(r)} = \mathbf{z}_{1989q2}$ $\forall r$, and compute:

$$\mathbf{z}_t^{(r)} = \widehat{\Psi}_0^{-1}\left(\widehat{\mathbf{a}}+\widehat{\Psi}_1\mathbf{z}_{t-1}^{(r)}+\widehat{\Psi}_2\mathbf{z}_{t-2}^{(r)}+\mathbf{u}_t^{(r)}\right) \qquad t = 1989q3, ..., 2020q1$$

3. Use the data computed at point 2 to estimate the bootstrapped coefficients for each replication:

$$\mathbf{z}_t^{(r)} = \widehat{\Psi}_0^{-1,(r)}\left(\widehat{\mathbf{a}}^{(r)}+\widehat{\Psi}_1^{(r)}\mathbf{z}_{t-1}^{(r)}+\widehat{\Psi}_2^{(r)}\mathbf{z}_{t-2}^{(r)}+\mathbf{u}_t^{(r)}\right).$$

The procedure just described can help evaluating $\mathbf{z}_t^{(r)}(baseline)$ vis-à-vis other scenarios $\mathbf{z}_t^{(r)}(Shock)$ with the major shock profiles derived in the paper.

## S.4 Additional empirical results

In this section we provide additional empirical results in support of our analyses. Table S.4 provides estimates of AR(1) and AR(2) processes for the sanctions intensity index, $s_t$. As explained in the paper, the process is highly persistent, and a first-order specification describes the process sufficiently well, with additional lags not being statistically significant. Table S.5 gives the estimates of first- and second-order autoregressive processes (AR) for the world output growth, and shows that the AR(1) specification used in the paper provides a reasonable approximation.

In the main paper we presented estimates of SVAR model under our preferred ordering, namely with the exchange rate variable ($\Delta e_{ft}$) included first, followed by money supply growth ($\Delta m_t$), inflation ($\Delta p_t$), and output growth ($\Delta y_t$), including the world output growth as the control variables. Tables S.6a to S.6d display the regression results including all the control variables, and a number of their sub-sets. As can be seen, the estimates of the effects of sanctions on domestic variables are highly stable and consistent across all specifications. It is also worth noting that changes in international oil prices do not have a statistically significant impact on the exchange rate, which could be due to the fact that once we condition on the sanctions variable, a rise in oil prices is less likely to benefit Iran when oil exports are severely limited due to sanctions. Also, none of the global factors seem to have any significant impact on Iran's output growth, partly due to Iran's relative economic and financial isolation from the rest of the global economy**.**

Tables S.7a to S.7d and S.8a to S.8d present results of the SVAR model given by Equation (5) of the paper, but with the different orderings of the domestic variables. Tables S.7a to S.7d provide the results when the domestic variables are ordered with inflation ($\Delta p_t$) first followed by the rate of change of the free market foreign exchange rate ($\Delta e_{ft}$), money supply growth ($\Delta m_t$), and output growth ($\Delta y_t$). Tables S.8a to S.8d give the results when the variables are ordered as $\Delta m_t$, $\Delta e_{ft}$, $\Delta p_t$, and $\Delta y_t$. As can be seen, re-ordering of the variables do not alter our main findings summarized in Section 6 of the paper.

Figure S.3 displays the impulse response results for one positive standard error shock to the global output growth on Iran's free market foreign exchange rate depreciation, inflation, and output growth.[13] As such, it complements the IRFs results from our SVAR model presented in Figure 3 of the paper. Following one quarter shock to global output growth, the Iran's rial appreciates by about 1.5 per cent in the same quarter. However, the results are not particularly persistent, and become quantitatively less important three quarters ahead, and lose statistical significance about five quarters ahead. The effects of global output growth on both inflation and Iran's output growth, on the other hand, are not statistically significant. These results are in line with Iran's relative economic isolation from the main advanced economies. Most of the global shocks are reflected in the movements of the free market foreign exchange rate, while the domestic economic mismanagement is a factor that can not be underplayed to explain the dynamics of the Iranian economy.

Table S.10 gives the estimates of the reduced form output growth equation given by (4), where we include both current lagged values of the sanctions intensity variable $s_t$. As can be seen, the estimates are very close to the ones presented in the paper, where only the lagged value of $s_t$ was included.

As reported in the paper, sanctions have adversely affected the growth of manufacturing and services, but seem to have had little impact on the growth of the agricultural sector. Here we also present results on the effects of sanctions on the rate of change of the shares of agriculture, manufacturing and mining, and services value added out of the total. To this end we estimate VAR(1) models in two of the three share variables at a time, since the sum of the shares add up to unity. The estimation results are summarized in Tables S.12, S.13 and S.14. As can be seen, sanctions have reduced the share of the manufacturing sector, whilst resulting in an increase in the share of the agricultural sector. The share of the services do not seem to be much affected by the sanctions. Overall, it is the manufacturing sector which is most affected by the sanctions.

In terms of labor statistics, we provide a robustness check for the effects of sanctions on the labor force participation rate in Iran with respect to other MENA countries. See Table S.18. We notice that sanctions induced a median decline which is perfectly consistent with the results obtained for the employment rate shown in Table S.15 of the paper.

Finally, we provide additional robustness checks on sanctions-induced education outcomes by considering changes in the number of teachers employed across different education grades, and the total number of schools and teachers. The estimates are summarized in Tables S.23, S.24, S.25, S.26 and S.27. These results support our main conclusion that the primary effects of sanctions has been on lower secondary and high school grades, with little impact on primary education (which is compulsory in Iran). In terms of the total number of schools and teachers, we find that sanctions have adversely affected the total number of schools, but the effects of sanctions on the total number of teachers is less clear cut.

[13] For a theoretical derivation, see Equation (14) in the main text.

Table S.4: Quarterly estimates of the sanctions intensity variable AR(1) and AR(2) models over the period 1989q1–2020q3

| | $s_t$ | |
|---|---|---|
| | (1) | (2) |
| $s_{t-1}$ | 0.743*** | 0.639*** |
| | (0.059) | (0.089) |
| $s_{t-2}$ | | 0.139 |
| | | (0.089) |
| Constant | 0.063*** | 0.055*** |
| | (0.018) | (0.019) |
| Adjusted $R^2$ | 0.551 | 0.557 |
| S.E. of regression ($\hat{\omega}_s$) | 0.125 | 0.125 |

**Notes**: Standard errors in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$. See Section S.2.1 in the data appendix of the online supplement for details on the construction of the sanctions intensity variable.

Table S.5: Quarterly estimates of the world real output growth AR(1) and AR(2) models over the period 1989q1–2020q1

| | $\Delta\bar{y}_{wt}$ | |
|---|---|---|
| | (1) | (2) |
| $\Delta\bar{y}_{w,t-1}$ | 0.468*** | 0.439*** |
| | (0.108) | (0.118) |
| $\Delta\bar{y}_{w,t-2}$ | | 0.073 |
| | | (0.118) |
| Constant | 0.005*** | 0.005*** |
| | (0.001) | (0.002) |
| Adjusted $R^2$ | 0.125 | 0.121 |
| Residual Std. Error | 0.006 | 0.006 |

**Notes**: $\Delta\bar{y}_{wt}$ is the quarterly world output growth: $\bar{y}_{wt} = \sum_{i=1}^{n} w_i y_{it}$, with $\{y_{it}\}_{i=1}^{n}$ being the natural log of real output for 33 major economies, and $w_i$ the GDP-PPP weights. See Section S.2.3 in the data appendix of the online supplement for details on the construction and sources of the data used.

Table S.6a: Quarterly estimates of the equation for the rate of change of the free market foreign exchange rate in the SVAR model of Iran with domestic variables ordered as: foreign exchange rate returns, money supply growth, inflation, and output growth, estimated over the period 1989q1–2020q1

| | $\Delta e_{ft}$ | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| $s_t$ | $0.311^{***}$ | $0.303^{***}$ | $0.295^{***}$ | $0.296^{***}$ | $0.297^{***}$ | $0.304^{***}$ | $0.303^{***}$ |
| | (0.061) | (0.061) | (0.061) | (0.061) | (0.060) | (0.061) | (0.061) |
| $s_{t-1}$ | $-0.243^{***}$ | $-0.245^{***}$ | $-0.238^{***}$ | $-0.240^{***}$ | $-0.236^{***}$ | $-0.242^{***}$ | $-0.243^{***}$ |
| | (0.064) | (0.063) | (0.064) | (0.063) | (0.063) | (0.063) | (0.063) |
| $\Delta e_{f,t-1}$ | $0.335^{***}$ | $0.341^{***}$ | $0.345^{***}$ | $0.337^{***}$ | $0.327^{***}$ | $0.328^{***}$ | $0.335^{***}$ |
| | (0.091) | (0.090) | (0.090) | (0.090) | (0.089) | (0.089) | (0.090) |
| $\Delta m_{t-1}$ | 0.298 | 0.350 | 0.366 | 0.321 | 0.379 | 0.385 | 0.406 |
| | (0.251) | (0.250) | (0.251) | (0.251) | (0.251) | (0.251) | (0.254) |
| $\Delta p_{t-1}$ | −0.304 | −0.376 | −0.366 | −0.413 | −0.357 | −0.391 | −0.411 |
| | (0.332) | (0.331) | (0.331) | (0.330) | (0.329) | (0.332) | (0.334) |
| $\Delta y_{t-1}$ | −0.135 | −0.126 | −0.133 | −0.146 | −0.113 | −0.114 | −0.108 |
| | (0.245) | (0.242) | (0.242) | (0.241) | (0.239) | (0.240) | (0.241) |
| $\Delta \bar{y}_{wt}$ | | $-2.059^{*}$ | $-2.513^{**}$ | $-3.467^{**}$ | $-3.211^{**}$ | $-3.048^{**}$ | $-3.105^{**}$ |
| | | (1.123) | (1.205) | (1.348) | (1.344) | (1.359) | (1.366) |
| $\Delta p_t^0$ | | | 0.054 | 0.037 | 0.079 | 0.076 | 0.094 |
| | | | (0.052) | (0.053) | (0.058) | (0.058) | (0.065) |
| $grv_t$ | | | | −0.365 | −0.387 | $-0.542^{*}$ | $-0.550^{*}$ |
| | | | | (0.237) | (0.235) | (0.299) | (0.300) |
| $\Delta \bar{e}_{wt}$ | | | | | $0.748^{*}$ | $0.739^{*}$ | $0.799^{*}$ |
| | | | | | (0.427) | (0.428) | (0.439) |
| $\Delta \overline{req}_{wt}$ | | | | | | −0.126 | −0.117 |
| | | | | | | (0.150) | (0.151) |
| $\Delta \bar{r}_{wt}$ | | | | | | | −7.731 |
| | | | | | | | (12.260) |
| Residual serial | 6.968 | 6.013 | 5.356 | 3.905 | 5.079 | 5.171 | 5.465 |
| correlation test | [0.138] | [0.198] | [0.253] | [0.419] | [0.279] | [0.270] | [0.243] |
| Adjusted $R^2$ | 0.225 | 0.240 | 0.240 | 0.249 | 0.263 | 0.261 | 0.257 |

**Notes**: The variables are ordered as: $\Delta e_{ft}$, $\Delta m_t$, $\Delta p_t$, and $\Delta y_t$, where: $\Delta e_{ft} = \ln(E_{ft}/E_{f,t-1})$, $E_{ft}$ is the quarterly rial/U.S. dollar free market exchange rate; $\Delta m_t = \ln(M_{2t}/M_{2,t-1})$, $M_{2t}$ is obtained by summing the aggregates $M1$ and "quasi-money"; $\Delta p_t = \ln(P_t/P_{t-1})$, $P_t$ is the quarterly consumer price index of Iran; $\Delta y_t = \ln(Y_t/Y_{t-1})$, $Y_t$ is the quarterly real output of Iran. $s_t$ is the quarterly sanctions intensity variable. $\Delta \bar{y}_{wt}$ is the quarterly world output growth, computed as $\bar{y}_{wt} = \sum_{i=1}^n w_i y_{it}$, with $\{y_{it}\}_{i=1}^n$ being the natural log of real output for 33 major economies, and $\{w_i\}_{i=1}^n$ are GDP-PPP weights. $\Delta p_t^0 = \ln(P_t^0/P_{t-1}^0)$, $P_t^0$ is the quarterly oil price (Brent crude). $grv_t$ is the quarterly global realized volatility. $\Delta \bar{e}_{wt}$ is the quarterly rate of change of the global real exchange rate vis-à-vis the U.S. dollar: $\bar{e}_{wt} = \sum_{i=1}^n w_i e_{it}$, $e_{it}$ is the natural log of the real exchange rate of country $i$ in quarter $t$. $\Delta \overline{req}_{wt}$ is the quarterly rate of change of the global real equity price index: $\overline{req}_{wt} = \sum_{i=1}^n w_i req_{it}$, $req_{it}$ is the natural log of the real equity price of country $i$ in quarter $t$. $\Delta \bar{r}_{wt}$ is the quarterly change of the global nominal long term interest rate: $\bar{r}_{wt} = \sum_{i=1}^n w_i r_{it}$, $r_{it}$ is the long term nominal interest rate of country $i$ in quarter $t$. Numbers in parentheses are standard errors, and those in square brackets are p-values. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. "Residual serial correlation test" is the Breusch–Godfrey LM test of serially uncorrelated errors with lag order of the test set to 4.
See Sections S.2.1, S.2.2, and S.2.3 in the data appendix of the online supplement for details on the construction of the sanctions intensity variable, calendar conversions, and sources of the data used.

Table S.6b: Quarterly estimates of the equation for the money supply growth in the SVAR model of Iran with domestic variables ordered as: foreign exchange rate returns, money supply growth, inflation, and output growth, estimated over the period 1989q1–2020q1

| | $\Delta m_t$ | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| $s_t$ | −0.001 | −0.001 | −0.001 | 0.002 | 0.002 | 0.002 | 0.002 |
| | (0.024) | (0.024) | (0.024) | (0.024) | (0.024) | (0.024) | (0.025) |
| $s_{t-1}$ | 0.011 | 0.011 | 0.012 | 0.009 | 0.009 | 0.008 | 0.008 |
| | (0.024) | (0.024) | (0.024) | (0.024) | (0.024) | (0.024) | (0.025) |
| $\Delta e_{ft}$ | −0.016 | −0.015 | −0.015 | −0.023 | −0.023 | −0.023 | −0.023 |
| | (0.032) | (0.033) | (0.033) | (0.033) | (0.034) | (0.034) | (0.034) |
| $\Delta e_{f,t-1}$ | −0.039 | −0.040 | −0.040 | −0.040 | −0.040 | −0.040 | −0.039 |
| | (0.034) | (0.034) | (0.034) | (0.034) | (0.034) | (0.034) | (0.035) |
| $\Delta m_{t-1}$ | −0.285*** | −0.289*** | −0.289*** | −0.304*** | −0.304*** | −0.304*** | −0.302*** |
| | (0.089) | (0.090) | (0.090) | (0.090) | (0.092) | (0.092) | (0.093) |
| $\Delta p_{t-1}$ | 0.126 | 0.132 | 0.132 | 0.110 | 0.110 | 0.108 | 0.106 |
| | (0.117) | (0.118) | (0.119) | (0.119) | (0.120) | (0.121) | (0.122) |
| $\Delta y_{t-1}$ | −0.064 | −0.064 | −0.064 | −0.070 | −0.070 | −0.070 | −0.070 |
| | (0.086) | (0.086) | (0.087) | (0.086) | (0.087) | (0.087) | (0.087) |
| $\Delta \bar{y}_{wt}$ | | 0.135 | 0.127 | −0.272 | −0.273 | −0.265 | −0.271 |
| | | (0.405) | (0.439) | (0.494) | (0.498) | (0.504) | (0.508) |
| $\Delta p_t^0$ | | | 0.001 | −0.006 | −0.006 | −0.006 | −0.005 |
| | | | (0.019) | (0.019) | (0.021) | (0.021) | (0.024) |
| $grv_t$ | | | | −0.145* | −0.145* | −0.154 | −0.155 |
| | | | | (0.085) | (0.086) | (0.110) | (0.111) |
| $\Delta \bar{e}_{wt}$ | | | | | −0.006 | −0.006 | −0.001 |
| | | | | | (0.156) | (0.157) | (0.162) |
| $\Delta \overline{req}_{wt}$ | | | | | | −0.007 | −0.006 |
| | | | | | | (0.055) | (0.055) |
| $\Delta \bar{r}_{wt}$ | | | | | | | −0.606 |
| | | | | | | | (4.461) |
| Residual serial | 7.051 | 7.165 | 7.174 | 6.363 | 6.411 | 6.653 | 6.650 |
| correlation test | [0.133] | [0.127] | [0.127] | [0.174] | [0.171] | [0.155] | [0.156] |
| Adjusted $R^2$ | 0.054 | 0.047 | 0.038 | 0.054 | 0.045 | 0.037 | 0.029 |

**Notes**: See the notes to Table S.6a for further details on the construction and sources of data used.

Table S.6c: Quarterly estimates of the equation for the inflation rate in the SVAR model of Iran with domestic variables ordered as: foreign exchange rate returns, money supply growth, inflation, and output growth, estimated over the period 1989q1–2020q1

| | $\Delta p_t$ | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| $s_t$ | $-0.033^{**}$ | $-0.033^{***}$ | $-0.032^{**}$ | $-0.032^{**}$ | $-0.033^{***}$ | $-0.030^{**}$ | $-0.030^{**}$ |
| | (0.013) | (0.012) | (0.013) | (0.013) | (0.012) | (0.013) | (0.013) |
| $s_{t-1}$ | $0.034^{**}$ | $0.037^{***}$ | $0.036^{***}$ | $0.036^{***}$ | $0.036^{***}$ | $0.033^{**}$ | $0.033^{**}$ |
| | (0.013) | (0.013) | (0.013) | (0.013) | (0.013) | (0.013) | (0.013) |
| $\Delta e_{ft}$ | $0.153^{***}$ | $0.162^{***}$ | $0.164^{***}$ | $0.163^{***}$ | $0.168^{***}$ | $0.166^{***}$ | $0.167^{***}$ |
| | (0.018) | (0.017) | (0.017) | (0.017) | (0.017) | (0.017) | (0.017) |
| $\Delta m_t$ | $-0.026$ | $-0.032$ | $-0.031$ | $-0.033$ | $-0.032$ | $-0.032$ | $-0.031$ |
| | (0.050) | (0.048) | (0.048) | (0.049) | (0.049) | (0.048) | (0.048) |
| $\Delta e_{f,t-1}$ | $-0.003$ | $-0.010$ | $-0.010$ | $-0.010$ | $-0.008$ | $-0.006$ | $-0.007$ |
| | (0.020) | (0.019) | (0.019) | (0.020) | (0.019) | (0.019) | (0.019) |
| $\Delta m_{t-1}$ | $-0.016$ | $-0.038$ | $-0.042$ | $-0.043$ | $-0.056$ | $-0.054$ | $-0.059$ |
| | (0.050) | (0.048) | (0.049) | (0.049) | (0.049) | (0.049) | (0.050) |
| $\Delta p_{t-1}$ | $0.456^{***}$ | $0.490^{***}$ | $0.484^{***}$ | $0.484^{***}$ | $0.460^{***}$ | $0.443^{***}$ | $0.441^{***}$ |
| | (0.090) | (0.086) | (0.087) | (0.087) | (0.087) | (0.088) | (0.088) |
| $\Delta y_{t-1}$ | 0.026 | 0.023 | 0.025 | 0.024 | 0.022 | 0.023 | 0.023 |
| | (0.048) | (0.046) | (0.046) | (0.047) | (0.046) | (0.046) | (0.046) |
| $\Delta p_{t-2}$ | $0.180^{**}$ | $0.174^{**}$ | $0.181^{**}$ | $0.179^{**}$ | $0.199^{**}$ | $0.207^{***}$ | $0.216^{***}$ |
| | (0.080) | (0.076) | (0.077) | (0.078) | (0.078) | (0.078) | (0.079) |
| $\Delta \overline{y}_{wt}$ | | $0.721^{***}$ | $0.801^{***}$ | $0.777^{***}$ | $0.751^{***}$ | $0.795^{***}$ | $0.813^{***}$ |
| | | (0.209) | (0.225) | (0.258) | (0.256) | (0.257) | (0.259) |
| $\Delta p_t^0$ | | | $-0.009$ | $-0.010$ | $-0.018$ | $-0.019^{*}$ | $-0.023^{*}$ |
| | | | (0.010) | (0.010) | (0.011) | (0.011) | (0.012) |
| $grv_t$ | | | | $-0.009$ | $-0.002$ | $-0.049$ | $-0.046$ |
| | | | | (0.045) | (0.045) | (0.057) | (0.057) |
| $\Delta \overline{e}_{wt}$ | | | | | $-0.138^{*}$ | $-0.141^{*}$ | $-0.156^{*}$ |
| | | | | | (0.081) | (0.081) | (0.084) |
| $\Delta \overline{req}_{wt}$ | | | | | | $-0.038$ | $-0.040$ |
| | | | | | | (0.028) | (0.028) |
| $\Delta \overline{r}_{wt}$ | | | | | | | 1.802 |
| | | | | | | | (2.287) |
| Residual serial | 13.954 | 8.236 | 9.993 | 10.393 | 10.984 | 9.239 | 9.526 |
| correlation test | [0.007] | [0.083] | [0.041] | [0.034] | [0.027] | [0.055] | [0.049] |
| Adjusted $R^2$ | 0.638 | 0.669 | 0.669 | 0.666 | 0.672 | 0.674 | 0.673 |

**Notes**: See the notes to Table S.6a for further details on the construction and sources of data used.

Table S.6d: Quarterly estimates of the equation for the output growth in the SVAR model of Iran with domestic variables ordered as: foreign exchange rate returns, money supply growth, inflation, and output growth, estimated over the period 1989q1–2020q1

| | $\Delta y_t$ | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| $s_t$ | 0.021 | 0.021 | 0.020 | 0.021 | 0.016 | 0.017 | 0.017 |
| | (0.025) | (0.025) | (0.025) | (0.025) | (0.025) | (0.025) | (0.026) |
| $s_{t-1}$ | $-0.057^{**}$ | $-0.058^{**}$ | $-0.057^{**}$ | $-0.058^{**}$ | $-0.055^{**}$ | $-0.056^{**}$ | $-0.057^{**}$ |
| | (0.025) | (0.026) | (0.026) | (0.026) | (0.026) | (0.026) | (0.026) |
| $\Delta e_{ft}$ | $-0.123^{***}$ | $-0.125^{***}$ | $-0.127^{***}$ | $-0.130^{***}$ | $-0.113^{**}$ | $-0.113^{**}$ | $-0.116^{**}$ |
| | (0.042) | (0.044) | (0.045) | (0.045) | (0.046) | (0.046) | (0.046) |
| $\Delta m_t$ | 0.096 | 0.097 | 0.097 | 0.088 | 0.086 | 0.085 | 0.084 |
| | (0.094) | (0.094) | (0.095) | (0.096) | (0.095) | (0.096) | (0.096) |
| $\Delta p_t$ | $0.335^{*}$ | $0.341^{*}$ | $0.348^{*}$ | $0.344^{*}$ | $0.304^{*}$ | 0.300 | $0.305^{*}$ |
| | (0.171) | (0.180) | (0.181) | (0.182) | (0.181) | (0.183) | (0.183) |
| $\Delta e_{f,t-1}$ | 0.033 | 0.033 | 0.035 | 0.034 | 0.034 | 0.034 | 0.038 |
| | (0.034) | (0.035) | (0.035) | (0.035) | (0.035) | (0.035) | (0.035) |
| $\Delta m_{t-1}$ | $-0.022$ | $-0.020$ | $-0.016$ | $-0.024$ | $-0.051$ | $-0.051$ | $-0.040$ |
| | (0.094) | (0.095) | (0.096) | (0.097) | (0.097) | (0.098) | (0.098) |
| $\Delta p_{t-1}$ | $-0.490^{***}$ | $-0.496^{***}$ | $-0.499^{***}$ | $-0.502^{***}$ | $-0.495^{***}$ | $-0.495^{***}$ | $-0.509^{***}$ |
| | (0.157) | (0.165) | (0.166) | (0.167) | (0.165) | (0.166) | (0.167) |
| $\Delta y_{t-1}$ | $-0.195^{**}$ | $-0.195^{**}$ | $-0.196^{**}$ | $-0.199^{**}$ | $-0.210^{**}$ | $-0.210^{**}$ | $-0.208^{**}$ |
| | (0.087) | (0.088) | (0.088) | (0.088) | (0.088) | (0.088) | (0.088) |
| $\Delta \overline{y}_{wt}$ | | $-0.049$ | $-0.145$ | $-0.278$ | $-0.313$ | $-0.298$ | $-0.335$ |
| | | (0.432) | (0.467) | (0.524) | (0.519) | (0.527) | (0.529) |
| $\Delta p_t^0$ | | | 0.010 | 0.008 | $-0.009$ | $-0.009$ | $-0.001$ |
| | | | (0.019) | (0.019) | (0.021) | (0.021) | (0.024) |
| $grv_t$ | | | | $-0.050$ | $-0.039$ | $-0.053$ | $-0.058$ |
| | | | | (0.088) | (0.088) | (0.112) | (0.113) |
| $\Delta \overline{e}_{wt}$ | | | | | $-0.291^{*}$ | $-0.291^{*}$ | $-0.261$ |
| | | | | | (0.159) | (0.160) | (0.164) |
| $\Delta \overline{req}_{wt}$ | | | | | | $-0.011$ | $-0.006$ |
| | | | | | | (0.055) | (0.056) |
| $\Delta \overline{r}_{wt}$ | | | | | | | $-3.734$ |
| | | | | | | | (4.487) |
| Residual serial correlation test | 7.157 [0.128] | 7.108 [0.130] | 6.991 [0.136] | 7.143 [0.129] | 7.813 [0.099] | 7.815 [0.099] | 7.782 [0.100] |
| Adjusted $R^2$ | 0.137 | 0.129 | 0.124 | 0.119 | 0.137 | 0.129 | 0.127 |

**Notes**: See the notes to Table S.6a for further details on the construction and sources of data used.

Table S.7a: Quarterly estimates of the equation for the inflation rate in the SVAR model of Iran with domestic variables ordered as: inflation, foreign exchange rate returns, money supply growth, and output growth, estimated over the period 1989q1–2020q1

| | $\Delta p_t$ | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| $s_t$ | 0.015 | 0.017 | 0.017 | 0.017 | 0.017 | 0.020 | 0.021 |
| | (0.015) | (0.015) | (0.015) | (0.015) | (0.015) | (0.015) | (0.016) |
| $s_{t-1}$ | −0.004 | −0.004 | −0.004 | −0.004 | −0.004 | −0.007 | −0.007 |
| | (0.016) | (0.016) | (0.016) | (0.016) | (0.016) | (0.016) | (0.016) |
| $\Delta e_{f,t-1}$ | 0.050** | 0.049** | 0.049** | 0.046* | 0.047* | 0.048* | 0.048* |
| | (0.024) | (0.024) | (0.024) | (0.025) | (0.025) | (0.025) | (0.025) |
| $\Delta m_{t-1}$ | 0.036 | 0.027 | 0.027 | 0.020 | 0.019 | 0.021 | 0.020 |
| | (0.061) | (0.062) | (0.062) | (0.062) | (0.063) | (0.063) | (0.064) |
| $\Delta p_{t-1}$ | 0.396*** | 0.411*** | 0.411*** | 0.411*** | 0.410*** | 0.384*** | 0.384*** |
| | (0.114) | (0.114) | (0.115) | (0.115) | (0.117) | (0.117) | (0.118) |
| $\Delta y_{t-1}$ | 0.009 | 0.007 | 0.007 | 0.003 | 0.003 | 0.005 | 0.004 |
| | (0.061) | (0.061) | (0.062) | (0.062) | (0.062) | (0.062) | (0.062) |
| $\Delta p_{t-2}$ | 0.194* | 0.192* | 0.192* | 0.181* | 0.182* | 0.194* | 0.196* |
| | (0.102) | (0.102) | (0.102) | (0.103) | (0.105) | (0.104) | (0.106) |
| $\Delta \bar{y}_{wt}$ | | 0.381 | 0.385 | 0.217 | 0.214 | 0.292 | 0.295 |
| | | (0.275) | (0.296) | (0.334) | (0.337) | (0.338) | (0.341) |
| $\Delta p_t^0$ | | | −0.001 | −0.003 | −0.004 | −0.005 | −0.007 |
| | | | (0.013) | (0.013) | (0.015) | (0.015) | (0.016) |
| $grv_t$ | | | | −0.064 | −0.064 | −0.135* | −0.135* |
| | | | | (0.059) | (0.059) | (0.074) | (0.075) |
| $\Delta \bar{e}_{wt}$ | | | | | −0.009 | −0.015 | −0.018 |
| | | | | | (0.108) | (0.108) | (0.111) |
| $\Delta \overline{req}_{wt}$ | | | | | | −0.059 | −0.059 |
| | | | | | | (0.037) | (0.038) |
| $\Delta \bar{r}_{wt}$ | | | | | | | 0.443 |
| | | | | | | | (3.081) |
| Residual serial | 3.293 | 3.802 | 3.941 | 4.168 | 4.101 | 4.563 | 4.734 |
| correlation test | [0.510] | [0.433] | [0.414] | [0.384] | [0.392] | [0.335] | [0.316] |
| Adjusted $R^2$ | 0.406 | 0.411 | 0.406 | 0.407 | 0.401 | 0.409 | 0.404 |

**Notes**: The variables are ordered as: $\Delta p_t$, $\Delta e_{ft}$, $\Delta m_t$, and $\Delta y_t$, where: $\Delta p_t = \ln(P_t/P_{t-1})$, $P_t$ is the quarterly consumer price index of Iran; $\Delta e_{ft} = \ln(E_{ft}/E_{f,t-1})$, $E_{ft}$ is the quarterly rial/U.S. dollar free market exchange rate; $\Delta m_t = \ln(M_{2t}/M_{2,t-1})$, $M_{2t}$ is obtained by summing the aggregates $M1$ and "quasi-money"; $\Delta y_t = \ln(Y_t/Y_{t-1})$, $Y_t$ is the quarterly real output of Iran. See the notes to Table S.6a for further details on the construction and sources of data used.

Table S.7b: Quarterly estimates of the equation for the rate of change of the free market foreign exchange rate in the SVAR model of Iran with domestic variables ordered as: inflation, foreign exchange rate returns, money supply growth, and output growth, estimated over the period 1989q1–2020q1

| | $\Delta e_{ft}$ | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| $s_t$ | 0.286*** | 0.272*** | 0.265*** | 0.266*** | 0.267*** | 0.266*** | 0.265*** |
| | (0.048) | (0.046) | (0.046) | (0.046) | (0.045) | (0.046) | (0.046) |
| $s_{t-1}$ | −0.250*** | −0.255*** | −0.248*** | −0.248*** | −0.245*** | −0.244*** | −0.245*** |
| | (0.050) | (0.048) | (0.048) | (0.048) | (0.047) | (0.048) | (0.048) |
| $\Delta p_t$ | 2.541*** | 2.672*** | 2.668*** | 2.637*** | 2.626*** | 2.631*** | 2.629*** |
| | (0.293) | (0.282) | (0.281) | (0.283) | (0.279) | (0.282) | (0.283) |
| $\Delta e_{f,t-1}$ | 0.257*** | 0.263*** | 0.267*** | 0.264*** | 0.255*** | 0.254*** | 0.261*** |
| | (0.072) | (0.068) | (0.068) | (0.068) | (0.067) | (0.068) | (0.068) |
| $\Delta m_{t-1}$ | 0.175 | 0.246 | 0.261 | 0.241 | 0.295 | 0.294 | 0.312 |
| | (0.198) | (0.189) | (0.189) | (0.190) | (0.189) | (0.190) | (0.192) |
| $\Delta p_{t-1}$ | −1.696*** | −1.877*** | −1.865*** | −1.870*** | −1.812*** | −1.811*** | −1.827*** |
| | (0.306) | (0.295) | (0.295) | (0.295) | (0.291) | (0.293) | (0.294) |
| $\Delta y_{t-1}$ | −0.082 | −0.066 | −0.073 | −0.079 | −0.049 | −0.049 | −0.044 |
| | (0.192) | (0.183) | (0.182) | (0.182) | (0.180) | (0.181) | (0.181) |
| $\Delta\bar{y}_{wt}$ | | −3.102*** | −3.515*** | −3.945*** | −3.704*** | −3.724*** | −3.774*** |
| | | (0.854) | (0.912) | (1.021) | (1.011) | (1.027) | (1.032) |
| $\Delta p_t^0$ | | | 0.049 | 0.041 | 0.081* | 0.081* | 0.097** |
| | | | (0.039) | (0.040) | (0.043) | (0.044) | (0.049) |
| $grv_t$ | | | | −0.169 | −0.190 | −0.172 | −0.180 |
| | | | | (0.180) | (0.178) | (0.229) | (0.230) |
| $\Delta\bar{e}_{wt}$ | | | | | 0.696** | 0.697** | 0.750** |
| | | | | | (0.321) | (0.322) | (0.331) |
| $\Delta\overline{req}_{wt}$ | | | | | | 0.014 | 0.022 |
| | | | | | | (0.114) | (0.115) |
| $\Delta\bar{r}_{wt}$ | | | | | | | −6.829 |
| | | | | | | | (9.235) |
| Residual serial | 11.560 | 8.001 | 8.665 | 7.670 | 8.223 | 8.175 | 7.930 |
| correlation test | [0.021] | [0.092] | [0.070] | [0.104] | [0.084] | [0.085] | [0.094] |
| Adjusted $R^2$ | 0.523 | 0.568 | 0.571 | 0.570 | 0.584 | 0.580 | 0.578 |

**Notes**: See the notes to Table S.6a for further details on the construction and sources of data used.

Table S.7c: Quarterly estimates of the equation for the money supply growth in the SVAR model of Iran with domestic variables ordered as: inflation, foreign exchange rate returns, money supply growth, and output growth, estimated over the period 1989q1–2020q1

| | $\Delta m_t$ | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| $s_t$ | −0.005 | −0.007 | −0.007 | −0.004 | −0.005 | −0.004 | −0.004 |
| | (0.025) | (0.025) | (0.025) | (0.025) | (0.025) | (0.025) | (0.025) |
| $s_{t-1}$ | 0.016 | 0.018 | 0.018 | 0.016 | 0.016 | 0.015 | 0.015 |
| | (0.025) | (0.025) | (0.025) | (0.025) | (0.025) | (0.025) | (0.026) |
| $\Delta p_t$ | −0.120 | −0.151 | −0.151 | −0.160 | −0.163 | −0.168 | −0.167 |
| | (0.169) | (0.177) | (0.179) | (0.177) | (0.179) | (0.181) | (0.182) |
| $\Delta e_{ft}$ | 0.002 | 0.010 | 0.010 | 0.003 | 0.005 | 0.005 | 0.005 |
| | (0.041) | (0.044) | (0.044) | (0.044) | (0.045) | (0.045) | (0.046) |
| $\Delta e_{f,t-1}$ | −0.041 | −0.044 | −0.044 | −0.044 | −0.044 | −0.044 | −0.044 |
| | (0.034) | (0.034) | (0.035) | (0.034) | (0.034) | (0.035) | (0.035) |
| $\Delta m_{t-1}$ | $-0.285^{***}$ | $-0.292^{***}$ | $-0.292^{***}$ | $-0.307^{***}$ | $-0.309^{***}$ | $-0.308^{***}$ | $-0.307^{***}$ |
| | (0.089) | (0.090) | (0.091) | (0.090) | (0.092) | (0.092) | (0.094) |
| $\Delta p_{t-1}$ | 0.198 | 0.226 | 0.226 | 0.209 | 0.210 | 0.209 | 0.207 |
| | (0.154) | (0.162) | (0.163) | (0.162) | (0.163) | (0.163) | (0.165) |
| $\Delta y_{t-1}$ | −0.064 | −0.064 | −0.064 | −0.070 | −0.071 | −0.071 | −0.071 |
| | (0.086) | (0.086) | (0.087) | (0.086) | (0.087) | (0.087) | (0.088) |
| $\Delta\bar{y}_{wt}$ | | 0.245 | 0.246 | −0.152 | −0.155 | −0.137 | −0.142 |
| | | (0.426) | (0.461) | (0.512) | (0.515) | (0.523) | (0.527) |
| $\Delta p_t^0$ | | | −0.0002 | −0.007 | −0.008 | −0.008 | −0.007 |
| | | | (0.019) | (0.019) | (0.021) | (0.021) | (0.024) |
| $grv_t$ | | | | $-0.147^{*}$ | $-0.147^{*}$ | −0.162 | −0.163 |
| | | | | (0.085) | (0.086) | (0.110) | (0.111) |
| $\Delta\bar{e}_{wt}$ | | | | | −0.023 | −0.024 | −0.020 |
| | | | | | (0.158) | (0.158) | (0.163) |
| $\Delta\overline{req}_{wt}$ | | | | | | −0.013 | −0.012 |
| | | | | | | (0.055) | (0.056) |
| $\Delta\bar{r}_{wt}$ | | | | | | | −0.449 |
| | | | | | | | (4.468) |
| Residual serial | 6.516 | 6.331 | 6.329 | 4.946 | 4.989 | 5.283 | 5.266 |
| correlation test | [0.164] | [0.176] | [0.176] | [0.293] | [0.288] | [0.259] | [0.261] |
| Adjusted $R^2$ | 0.050 | 0.044 | 0.036 | 0.052 | 0.044 | 0.036 | 0.027 |

**Notes**: See the notes to Table S.6a for further details on the construction and sources of data used.

Table S.7d: Quarterly estimates of the equation for the output growth in the SVAR model of Iran with domestic variables ordered as: inflation, foreign exchange rate returns, money supply growth, and output growth, estimated over the period 1989q1–2020q1

| | $\Delta y_t$ | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| $s_t$ | 0.021 | 0.021 | 0.020 | 0.021 | 0.016 | 0.017 | 0.017 |
| | (0.025) | (0.025) | (0.025) | (0.025) | (0.025) | (0.025) | (0.026) |
| $s_{t-1}$ | $-0.057^{**}$ | $-0.058^{**}$ | $-0.057^{**}$ | $-0.058^{**}$ | $-0.055^{**}$ | $-0.056^{**}$ | $-0.057^{**}$ |
| | (0.025) | (0.026) | (0.026) | (0.026) | (0.026) | (0.026) | (0.026) |
| $\Delta e_{ft}$ | $-0.123^{***}$ | $-0.125^{***}$ | $-0.127^{***}$ | $-0.130^{***}$ | $-0.113^{**}$ | $-0.113^{**}$ | $-0.116^{**}$ |
| | (0.042) | (0.044) | (0.045) | (0.045) | (0.046) | (0.046) | (0.046) |
| $\Delta m_t$ | 0.096 | 0.097 | 0.097 | 0.088 | 0.086 | 0.085 | 0.084 |
| | (0.094) | (0.094) | (0.095) | (0.096) | (0.095) | (0.096) | (0.096) |
| $\Delta p_t$ | $0.335^{*}$ | $0.341^{*}$ | $0.348^{*}$ | $0.344^{*}$ | $0.304^{*}$ | 0.300 | $0.305^{*}$ |
| | (0.171) | (0.180) | (0.181) | (0.182) | (0.181) | (0.183) | (0.183) |
| $\Delta e_{f,t-1}$ | 0.033 | 0.033 | 0.035 | 0.034 | 0.034 | 0.034 | 0.038 |
| | (0.034) | (0.035) | (0.035) | (0.035) | (0.035) | (0.035) | (0.035) |
| $\Delta m_{t-1}$ | −0.022 | −0.020 | −0.016 | −0.024 | −0.051 | −0.051 | −0.040 |
| | (0.094) | (0.095) | (0.096) | (0.097) | (0.097) | (0.098) | (0.098) |
| $\Delta p_{t-1}$ | $-0.490^{***}$ | $-0.496^{***}$ | $-0.499^{***}$ | $-0.502^{***}$ | $-0.495^{***}$ | $-0.495^{***}$ | $-0.509^{***}$ |
| | (0.157) | (0.165) | (0.166) | (0.167) | (0.165) | (0.166) | (0.167) |
| $\Delta y_{t-1}$ | $-0.195^{**}$ | $-0.195^{**}$ | $-0.196^{**}$ | $-0.199^{**}$ | $-0.210^{**}$ | $-0.210^{**}$ | $-0.208^{**}$ |
| | (0.087) | (0.088) | (0.088) | (0.088) | (0.088) | (0.088) | (0.088) |
| $\Delta \bar{y}_{wt}$ | | −0.049 | −0.145 | −0.278 | −0.313 | −0.298 | −0.335 |
| | | (0.432) | (0.467) | (0.524) | (0.519) | (0.527) | (0.529) |
| $\Delta p_t^0$ | | | 0.010 | 0.008 | −0.009 | −0.009 | −0.001 |
| | | | (0.019) | (0.019) | (0.021) | (0.021) | (0.024) |
| $grv_t$ | | | | −0.050 | −0.039 | −0.053 | −0.058 |
| | | | | (0.088) | (0.088) | (0.112) | (0.113) |
| $\Delta \bar{e}_{wt}$ | | | | | $-0.291^{*}$ | $-0.291^{*}$ | −0.261 |
| | | | | | (0.159) | (0.160) | (0.164) |
| $\Delta \overline{req}_{wt}$ | | | | | | −0.011 | −0.006 |
| | | | | | | (0.055) | (0.056) |
| $\Delta \bar{r}_{wt}$ | | | | | | | −3.734 |
| | | | | | | | (4.487) |
| Residual serial correlation test | 7.157 [0.128] | 7.108 [0.130] | 6.991 [0.136] | 7.143 [0.129] | 7.813 [0.099] | 7.815 [0.099] | 7.782 [0.100] |
| Adjusted $R^2$ | 0.137 | 0.129 | 0.124 | 0.119 | 0.137 | 0.129 | 0.127 |

**Notes**: See the notes to Table S.6a for further details on the construction and sources of data used.

Table S.8a: Quarterly estimates of the equation for the money supply growth in the SVAR model of Iran with domestic variables ordered as: money supply growth, foreign exchange rate returns, inflation, and output growth, estimated over the period 1989q1–2020q1

| | $\Delta m_t$ | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| $s_t$ | −0.006 | −0.005 | −0.005 | −0.005 | −0.005 | −0.005 | −0.005 |
| | (0.021) | (0.022) | (0.022) | (0.022) | (0.022) | (0.022) | (0.022) |
| $s_{t-1}$ | 0.015 | 0.015 | 0.015 | 0.014 | 0.014 | 0.014 | 0.014 |
| | (0.022) | (0.022) | (0.023) | (0.023) | (0.023) | (0.023) | (0.023) |
| $\Delta e_{f,t-1}$ | −0.044 | −0.045 | −0.045 | −0.048 | −0.047 | −0.047 | −0.047 |
| | (0.032) | (0.032) | (0.032) | (0.032) | (0.032) | (0.032) | (0.033) |
| $\Delta m_{t-1}$ | −0.290*** | −0.294*** | −0.294*** | −0.311*** | −0.313*** | −0.312*** | −0.311*** |
| | (0.088) | (0.089) | (0.089) | (0.089) | (0.090) | (0.091) | (0.092) |
| $\Delta p_{t-1}$ | 0.131 | 0.137 | 0.137 | 0.120 | 0.118 | 0.117 | 0.116 |
| | (0.116) | (0.117) | (0.118) | (0.118) | (0.119) | (0.120) | (0.121) |
| $\Delta y_{t-1}$ | −0.061 | −0.062 | −0.062 | −0.067 | −0.068 | −0.068 | −0.067 |
| | (0.086) | (0.086) | (0.086) | (0.086) | (0.086) | (0.087) | (0.087) |
| $\Delta \overline{y}_{wt}$ | | 0.165 | 0.164 | −0.193 | −0.201 | −0.195 | −0.198 |
| | | (0.398) | (0.429) | (0.480) | (0.485) | (0.492) | (0.495) |
| $\Delta p_t^0$ | | | 0.0001 | −0.006 | −0.008 | −0.008 | −0.007 |
| | | | (0.018) | (0.019) | (0.021) | (0.021) | (0.023) |
| $grv_t$ | | | | −0.137 | −0.136 | −0.141 | −0.142 |
| | | | | (0.084) | (0.085) | (0.108) | (0.109) |
| $\Delta \overline{e}_{wt}$ | | | | | −0.023 | −0.023 | −0.020 |
| | | | | | (0.154) | (0.155) | (0.159) |
| $\Delta \overline{req}_{wt}$ | | | | | | −0.004 | −0.004 |
| | | | | | | (0.054) | (0.055) |
| $\Delta \overline{r}_{wt}$ | | | | | | | −0.427 |
| | | | | | | | (4.442) |
| Residual serial | 7.577 | 7.715 | 7.720 | 7.444 | 7.503 | 7.676 | 7.718 |
| correlation test | [0.108] | [0.103] | [0.102] | [0.114] | [0.112] | [0.104] | [0.102] |
| Adjusted $R^2$ | 0.060 | 0.053 | 0.045 | 0.058 | 0.050 | 0.042 | 0.033 |

**Notes**: The variables are ordered as: $\Delta m_t$, $\Delta e_{ft}$, $\Delta p_t$, and $\Delta y_t$, where: $\Delta m_t = \ln(M_{2t}/M_{2,t-1})$, $M_{2t}$ is obtained by summing the aggregates $M1$ and "quasi-money"; $\Delta e_{ft} = \ln(E_{ft}/E_{f,t-1})$, $E_{ft}$ is the quarterly rial/U.S. dollar free market exchange rate; $\Delta p_t = \ln(P_t/P_{t-1})$, $P_t$ is the quarterly consumer price index of Iran; $\Delta y_t = \ln(Y_t/Y_{t-1})$, $Y_t$ is the quarterly real output of Iran. See the notes to Table S.6a for further details on the construction and sources of data used.

Table S.8b: Quarterly estimates of the equation for the rate of change of the free market foreign exchange rate in the SVAR model of Iran with domestic variables ordered as: money supply growth, foreign exchange rate returns, inflation, and output growth, estimated over the period 1989q1–2020q1

| | $\Delta e_{ft}$ | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| $s_t$ | 0.310*** | 0.302*** | 0.295*** | 0.295*** | 0.296*** | 0.303*** | 0.302*** |
| | (0.062) | (0.061) | (0.061) | (0.061) | (0.061) | (0.061) | (0.061) |
| $s_{t-1}$ | −0.241*** | −0.244*** | −0.236*** | −0.237*** | −0.234*** | −0.240*** | −0.241*** |
| | (0.064) | (0.064) | (0.064) | (0.064) | (0.063) | (0.063) | (0.064) |
| $\Delta m_t$ | −0.134 | −0.116 | −0.116 | −0.180 | −0.174 | −0.175 | −0.177 |
| | (0.264) | (0.262) | (0.262) | (0.263) | (0.260) | (0.261) | (0.261) |
| $\Delta e_{f,t-1}$ | 0.329*** | 0.336*** | 0.340*** | 0.329*** | 0.319*** | 0.320*** | 0.327*** |
| | (0.092) | (0.091) | (0.091) | (0.091) | (0.090) | (0.090) | (0.091) |
| $\Delta m_{t-1}$ | 0.260 | 0.316 | 0.331 | 0.265 | 0.324 | 0.330 | 0.351 |
| | (0.263) | (0.263) | (0.263) | (0.264) | (0.264) | (0.265) | (0.267) |
| $\Delta p_{t-1}$ | −0.286 | −0.360 | −0.350 | −0.391 | −0.337 | −0.371 | −0.391 |
| | (0.335) | (0.334) | (0.334) | (0.333) | (0.331) | (0.334) | (0.336) |
| $\Delta y_{t-1}$ | −0.143 | −0.134 | −0.140 | −0.158 | −0.125 | −0.126 | −0.120 |
| | (0.246) | (0.244) | (0.244) | (0.242) | (0.241) | (0.241) | (0.242) |
| $\Delta\bar{y}_{wt}$ | | −2.040* | −2.494** | −3.502** | −3.246** | −3.082** | −3.140** |
| | | (1.128) | (1.210) | (1.352) | (1.348) | (1.364) | (1.370) |
| $\Delta p_t^0$ | | | 0.054 | 0.035 | 0.078 | 0.075 | 0.093 |
| | | | (0.052) | (0.053) | (0.058) | (0.058) | (0.065) |
| $grv_t$ | | | | −0.390 | −0.411* | −0.567* | −0.576* |
| | | | | (0.240) | (0.238) | (0.302) | (0.303) |
| $\Delta\bar{e}_{wt}$ | | | | | 0.744* | 0.735* | 0.795* |
| | | | | | (0.428) | (0.429) | (0.440) |
| $\Delta\overline{req}_{wt}$ | | | | | | −0.127 | −0.117 |
| | | | | | | (0.151) | (0.152) |
| $\Delta\bar{r}_{wt}$ | | | | | | | −7.807 |
| | | | | | | | (12.290) |
| Residual serial | 6.955 | 6.089 | 5.471 | 4.159 | 5.183 | 5.145 | 5.412 |
| correlation test | [0.138] | [0.193] | [0.242] | [0.385] | [0.269] | [0.273] | [0.248] |
| Adjusted $R^2$ | 0.220 | 0.235 | 0.235 | 0.246 | 0.259 | 0.257 | 0.253 |

**Notes**: See the notes to Table S.6a for further details on the construction and sources of data used.

Table S.8c: Quarterly estimates of the equation for the inflation rate in the SVAR model of Iran with domestic variables ordered as: money supply growth, foreign exchange rate returns, inflation, and output growth, estimated over the period 1989q1–2020q1

| | $\Delta p_t$ | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| $s_t$ | $-0.033^{**}$ | $-0.033^{***}$ | $-0.032^{**}$ | $-0.032^{**}$ | $-0.033^{***}$ | $-0.030^{**}$ | $-0.030^{**}$ |
| | (0.013) | (0.012) | (0.013) | (0.013) | (0.012) | (0.013) | (0.013) |
| $s_{t-1}$ | $0.034^{**}$ | $0.037^{***}$ | $0.036^{***}$ | $0.036^{***}$ | $0.036^{***}$ | $0.033^{**}$ | $0.033^{**}$ |
| | (0.013) | (0.013) | (0.013) | (0.013) | (0.013) | (0.013) | (0.013) |
| $\Delta e_{ft}$ | $0.153^{***}$ | $0.162^{***}$ | $0.164^{***}$ | $0.163^{***}$ | $0.168^{***}$ | $0.166^{***}$ | $0.167^{***}$ |
| | (0.018) | (0.017) | (0.017) | (0.017) | (0.017) | (0.017) | (0.017) |
| $\Delta m_t$ | $-0.026$ | $-0.032$ | $-0.031$ | $-0.033$ | $-0.032$ | $-0.032$ | $-0.031$ |
| | (0.050) | (0.048) | (0.048) | (0.049) | (0.049) | (0.048) | (0.048) |
| $\Delta e_{f,t-1}$ | $-0.003$ | $-0.010$ | $-0.010$ | $-0.010$ | $-0.008$ | $-0.006$ | $-0.007$ |
| | (0.020) | (0.019) | (0.019) | (0.020) | (0.019) | (0.019) | (0.019) |
| $\Delta m_{t-1}$ | $-0.016$ | $-0.038$ | $-0.042$ | $-0.043$ | $-0.056$ | $-0.054$ | $-0.059$ |
| | (0.050) | (0.048) | (0.049) | (0.049) | (0.049) | (0.049) | (0.050) |
| $\Delta p_{t-1}$ | $0.456^{***}$ | $0.490^{***}$ | $0.484^{***}$ | $0.484^{***}$ | $0.460^{***}$ | $0.443^{***}$ | $0.441^{***}$ |
| | (0.090) | (0.086) | (0.087) | (0.087) | (0.087) | (0.088) | (0.088) |
| $\Delta y_{t-1}$ | 0.026 | 0.023 | 0.025 | 0.024 | 0.022 | 0.023 | 0.023 |
| | (0.048) | (0.046) | (0.046) | (0.047) | (0.046) | (0.046) | (0.046) |
| $\Delta p_{t-2}$ | $0.180^{**}$ | $0.174^{**}$ | $0.181^{**}$ | $0.179^{**}$ | $0.199^{**}$ | $0.207^{***}$ | $0.216^{***}$ |
| | (0.080) | (0.076) | (0.077) | (0.078) | (0.078) | (0.078) | (0.079) |
| $\Delta \overline{y}_{wt}$ | | $0.721^{***}$ | $0.801^{***}$ | $0.777^{***}$ | $0.751^{***}$ | $0.795^{***}$ | $0.813^{***}$ |
| | | (0.209) | (0.225) | (0.258) | (0.256) | (0.257) | (0.259) |
| $\Delta p_t^0$ | | | $-0.009$ | $-0.010$ | $-0.018$ | $-0.019^{*}$ | $-0.023^{*}$ |
| | | | (0.010) | (0.010) | (0.011) | (0.011) | (0.012) |
| $grv_t$ | | | | $-0.009$ | $-0.002$ | $-0.049$ | $-0.046$ |
| | | | | (0.045) | (0.045) | (0.057) | (0.057) |
| $\Delta \overline{e}_{wt}$ | | | | | $-0.138^{*}$ | $-0.141^{*}$ | $-0.156^{*}$ |
| | | | | | (0.081) | (0.081) | (0.084) |
| $\Delta \overline{req}_{wt}$ | | | | | | $-0.038$ | $-0.040$ |
| | | | | | | (0.028) | (0.028) |
| $\Delta \overline{r}_{wt}$ | | | | | | | 1.802 |
| | | | | | | | (2.287) |
| Residual serial | 13.954 | 8.236 | 9.993 | 10.393 | 10.984 | 9.239 | 9.526 |
| correlation test | [0.007] | [0.083] | [0.041] | [0.034] | [0.027] | [0.055] | [0.049] |
| Adjusted $R^2$ | 0.638 | 0.669 | 0.669 | 0.666 | 0.672 | 0.674 | 0.673 |

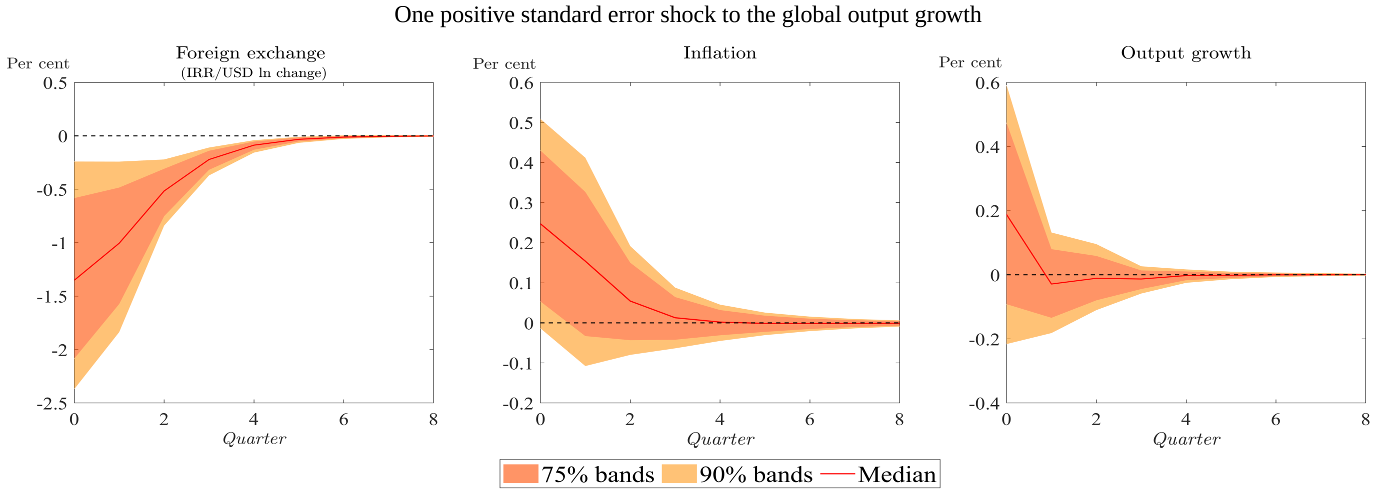
**Notes**: See the notes to Table S.6a for further details on the construction and sources of data used.

Table S.8d: Quarterly estimates of the equation for the output growth in the SVAR model of Iran with domestic variables ordered as: money supply growth, foreign exchange rate returns, inflation, and output growth, estimated over the period 1989q1–2020q1

| | $\Delta y_t$ | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| $s_t$ | 0.021 | 0.021 | 0.020 | 0.021 | 0.016 | 0.017 | 0.017 |
| | (0.025) | (0.025) | (0.025) | (0.025) | (0.025) | (0.025) | (0.026) |
| $s_{t-1}$ | $-0.057^{**}$ | $-0.058^{**}$ | $-0.057^{**}$ | $-0.058^{**}$ | $-0.055^{**}$ | $-0.056^{**}$ | $-0.057^{**}$ |
| | (0.025) | (0.026) | (0.026) | (0.026) | (0.026) | (0.026) | (0.026) |
| $\Delta e_{ft}$ | $-0.123^{***}$ | $-0.125^{***}$ | $-0.127^{***}$ | $-0.130^{***}$ | $-0.113^{**}$ | $-0.113^{**}$ | $-0.116^{**}$ |
| | (0.042) | (0.044) | (0.045) | (0.045) | (0.046) | (0.046) | (0.046) |
| $\Delta m_t$ | 0.096 | 0.097 | 0.097 | 0.088 | 0.086 | 0.085 | 0.084 |
| | (0.094) | (0.094) | (0.095) | (0.096) | (0.095) | (0.096) | (0.096) |
| $\Delta p_t$ | $0.335^{*}$ | $0.341^{*}$ | $0.348^{*}$ | $0.344^{*}$ | $0.304^{*}$ | 0.300 | $0.305^{*}$ |
| | (0.171) | (0.180) | (0.181) | (0.182) | (0.181) | (0.183) | (0.183) |
| $\Delta e_{f,t-1}$ | 0.033 | 0.033 | 0.035 | 0.034 | 0.034 | 0.034 | 0.038 |
| | (0.034) | (0.035) | (0.035) | (0.035) | (0.035) | (0.035) | (0.035) |
| $\Delta m_{t-1}$ | $-0.022$ | $-0.020$ | $-0.016$ | $-0.024$ | $-0.051$ | $-0.051$ | $-0.040$ |
| | (0.094) | (0.095) | (0.096) | (0.097) | (0.097) | (0.098) | (0.098) |
| $\Delta p_{t-1}$ | $-0.490^{***}$ | $-0.496^{***}$ | $-0.499^{***}$ | $-0.502^{***}$ | $-0.495^{***}$ | $-0.495^{***}$ | $-0.509^{***}$ |
| | (0.157) | (0.165) | (0.166) | (0.167) | (0.165) | (0.166) | (0.167) |
| $\Delta y_{t-1}$ | $-0.195^{**}$ | $-0.195^{**}$ | $-0.196^{**}$ | $-0.199^{**}$ | $-0.210^{**}$ | $-0.210^{**}$ | $-0.208^{**}$ |
| | (0.087) | (0.088) | (0.088) | (0.088) | (0.088) | (0.088) | (0.088) |
| $\Delta \overline{y}_{wt}$ | | $-0.049$ | $-0.145$ | $-0.278$ | $-0.313$ | $-0.298$ | $-0.335$ |
| | | (0.432) | (0.467) | (0.524) | (0.519) | (0.527) | (0.529) |
| $\Delta p_t^0$ | | | 0.010 | 0.008 | $-0.009$ | $-0.009$ | $-0.001$ |
| | | | (0.019) | (0.019) | (0.021) | (0.021) | (0.024) |
| $grv_t$ | | | | $-0.050$ | $-0.039$ | $-0.053$ | $-0.058$ |
| | | | | (0.088) | (0.088) | (0.112) | (0.113) |
| $\Delta \overline{e}_{wt}$ | | | | | $-0.291^{*}$ | $-0.291^{*}$ | $-0.261$ |
| | | | | | (0.159) | (0.160) | (0.164) |
| $\Delta \overline{req}_{wt}$ | | | | | | $-0.011$ | $-0.006$ |
| | | | | | | (0.055) | (0.056) |
| $\Delta \overline{r}_{wt}$ | | | | | | | $-3.734$ |
| | | | | | | | (4.487) |
| Residual serial correlation test | 7.157 [0.128] | 7.108 [0.130] | 6.991 [0.136] | 7.143 [0.129] | 7.813 [0.099] | 7.815 [0.099] | 7.782 [0.100] |
| Adjusted $R^2$ | 0.137 | 0.129 | 0.124 | 0.119 | 0.137 | 0.129 | 0.127 |

**Notes**: See the notes to Table S.6a for further details on the construction and sources of data used.

Figure S.3: Impulse responses of the effects of world output growth shocks on foreign exchange, inflation, and Iran output growth




**Notes**: The structural VAR system studied in Equation (8) is composed of five variables. The current figure supplements the four panels available in Figure 3.

Table S.9: Estimates of reduced form Iran's output growth equation estimated over the period 1989q1–2020q1

| | $\Delta y_t$ | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| $s_{t-1}(\beta_{s_{t-1}})$ | $-0.037^{**}$ | $-0.035^{**}$ | $-0.035^{**}$ | $-0.035^{**}$ | $-0.037^{**}$ | $-0.037^{**}$ | $-0.038^{**}$ |
| | (0.016) | (0.016) | (0.016) | (0.016) | (0.016) | (0.016) | (0.016) |
| $\Delta y_{t-1}(\lambda_{\Delta y_{t-1}})$ | $-0.186^{**}$ | $-0.188^{**}$ | $-0.188^{**}$ | $-0.190^{**}$ | $-0.206^{**}$ | $-0.206^{**}$ | $-0.204^{**}$ |
| | (0.089) | (0.089) | (0.089) | (0.090) | (0.088) | (0.089) | (0.089) |
| $\Delta e_{f,t-1}$ | $-0.000$ | $-0.002$ | $-0.002$ | $-0.002$ | 0.003 | 0.003 | 0.006 |
| | (0.033) | (0.033) | (0.033) | (0.033) | (0.033) | (0.033) | (0.033) |
| $\Delta m_{t-1}$ | $-0.068$ | $-0.077$ | $-0.077$ | $-0.082$ | $-0.110$ | $-0.109$ | $-0.101$ |
| | (0.092) | (0.092) | (0.093) | (0.094) | (0.093) | (0.093) | (0.094) |
| $\Delta p_{t-1}$ | $-0.264^{**}$ | $-0.250^{**}$ | $-0.250^{**}$ | $-0.255^{**}$ | $-0.283^{**}$ | $-0.287^{**}$ | $-0.295^{**}$ |
| | (0.120) | (0.121) | (0.122) | (0.123) | (0.121) | (0.122) | (0.123) |
| $\Delta \bar{y}_{wt}$ | | 0.375 | 0.353 | 0.245 | 0.119 | 0.140 | 0.119 |
| | | (0.413) | (0.443) | (0.501) | (0.494) | (0.501) | (0.503) |
| $\Delta p_t^0$ | | | 0.003 | 0.001 | $-0.020$ | $-0.021$ | $-0.014$ |
| | | | (0.019) | (0.020) | (0.021) | (0.021) | (0.024) |
| $grv_t$ | | | | $-0.041$ | $-0.030$ | $-0.052$ | $-0.055$ |
| | | | | (0.088) | (0.087) | (0.110) | (0.111) |
| $\Delta \bar{e}_{wt}$ | | | | | $-0.370^{**}$ | $-0.372^{**}$ | $-0.349^{**}$ |
| | | | | | (0.158) | (0.158) | (0.163) |
| $\Delta \overline{req}_{wt}$ | | | | | | $-0.018$ | $-0.014$ |
| | | | | | | (0.055) | (0.056) |
| $\Delta \bar{r}_{wt}$ | | | | | | | $-2.932$ |
| | | | | | | | (4.542) |
| $\beta_{s_{t-1}}/(1-\lambda_{\Delta y_{t-1}})$ | $-0.031^{**}$ | $-0.029^{**}$ | $-0.029^{**}$ | $-0.029^{**}$ | $-0.031^{**}$ | $-0.031^{**}$ | $-0.031^{**}$ |
| | (0.013) | (0.013) | (0.013) | (0.013) | (0.013) | (0.013) | (0.013) |
| Adjusted $R^2$ | 0.093 | 0.091 | 0.084 | 0.077 | 0.112 | 0.105 | 0.100 |

**Notes**: $\beta_{s_{t-1}}$ and $\lambda_{\Delta y_{t-1}}$ are the coefficients of $s_{t-1}$ and $\Delta y_{t-1}$, respectively; $\beta_{s_{t-1}}/(1-\lambda_{\Delta y_{t-1}})$ represents the long run effect of sanctions on output growth. See Chapter 6 of Pesaran (2015). See the notes to Table S.6a for further details on the construction and sources of data used.

Table S.10: Estimates of reduced form Iran's output growth equation including contemporaneous sanction variable and estimated over the period 1989q1–2020q1

| | $\Delta y_t$ | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| $s_t(\beta_{s_t})$ | $-0.015$ | $-0.013$ | $-0.014$ | $-0.014$ | $-0.014$ | $-0.013$ | $-0.014$ |
| | (0.022) | (0.022) | (0.023) | (0.023) | (0.022) | (0.023) | (0.023) |
| $s_{t-1}(\beta_{s_{t-1}})$ | $-0.025$ | $-0.025$ | $-0.024$ | $-0.024$ | $-0.026$ | $-0.027$ | $-0.027$ |
| | (0.023) | (0.023) | (0.024) | (0.024) | (0.023) | (0.023) | (0.024) |
| $\Delta y_{t-1}(\lambda_{\Delta y_{t-1}})$ | $-0.191^{**}$ | $-0.192^{**}$ | $-0.193^{**}$ | $-0.194^{**}$ | $-0.211^{**}$ | $-0.211^{**}$ | $-0.208^{**}$ |
| | (0.089) | (0.089) | (0.090) | (0.090) | (0.089) | (0.089) | (0.089) |
| $\Delta e_{f,t-1}$ | $-0.002$ | $-0.004$ | $-0.003$ | $-0.004$ | 0.001 | 0.001 | 0.004 |
| | (0.033) | (0.033) | (0.033) | (0.034) | (0.033) | (0.033) | (0.034) |
| $\Delta m_{t-1}$ | $-0.070$ | $-0.079$ | $-0.078$ | $-0.083$ | $-0.111$ | $-0.110$ | $-0.102$ |
| | (0.092) | (0.092) | (0.093) | (0.094) | (0.093) | (0.093) | (0.094) |
| $\Delta p_{t-1}$ | $-0.257^{**}$ | $-0.244^{**}$ | $-0.243^{**}$ | $-0.249^{**}$ | $-0.276^{**}$ | $-0.280^{**}$ | $-0.287^{**}$ |
| | (0.121) | (0.122) | (0.123) | (0.124) | (0.122) | (0.123) | (0.124) |
| $\Delta \bar{y}_{wt}$ | | 0.357 | 0.322 | 0.216 | 0.089 | 0.106 | 0.084 |
| | | (0.415) | (0.447) | (0.505) | (0.498) | (0.505) | (0.508) |
| $\Delta p_t^0$ | | | 0.004 | 0.002 | $-0.019$ | $-0.019$ | $-0.012$ |
| | | | (0.019) | (0.020) | (0.021) | (0.021) | (0.024) |
| $grv_t$ | | | | $-0.041$ | $-0.030$ | $-0.046$ | $-0.049$ |
| | | | | (0.089) | (0.087) | (0.111) | (0.112) |
| $\Delta \bar{e}_{wt}$ | | | | | $-0.371^{**}$ | $-0.372^{**}$ | $-0.349^{**}$ |
| | | | | | (0.158) | (0.159) | (0.163) |
| $\Delta \overline{req}_{wt}$ | | | | | | $-0.013$ | $-0.009$ |
| | | | | | | (0.056) | (0.056) |
| $\Delta \bar{r}_{wt}$ | | | | | | | $-2.982$ |
| | | | | | | | (4.556) |
| $\beta_{s_t} + \beta_{s_{t-1}}$ | $-0.040^{**}$ | $-0.038^{**}$ | $-0.038^{**}$ | $-0.038^{**}$ | $-0.040^{**}$ | $-0.040^{**}$ | $-0.041^{**}$ |
| | (0.016) | (0.017) | (0.017) | (0.017) | (0.017) | (0.017) | (0.017) |
| $(\beta_{s_t} + \beta_{s_{t-1}})/(1-\lambda_{\Delta y_{t-1}})$ | $-0.034^{**}$ | $-0.032^{**}$ | $-0.032^{**}$ | $-0.032^{**}$ | $-0.033^{**}$ | $-0.033^{**}$ | $-0.034^{**}$ |
| | (0.014) | (0.014) | (0.014) | (0.014) | (0.013) | (0.014) | (0.014) |
| Adjusted $R^2$ | 0.088 | 0.086 | 0.079 | 0.072 | 0.107 | 0.100 | 0.095 |

**Notes**: $\beta_{s_t}, \beta_{s_{t-1}}$ and $\lambda_{\Delta y_{t-1}}$ are the coefficients of $s_t, s_{t-1}$ and $\Delta y_{t-1}$, respectively; $(\beta_{s_t} + \beta_{s_{t-1}})/(1- \lambda_{\Delta y_{t-1}})$ represents the long run effect of sanctions on output growth. See Chapter 6 of Pesaran (2015). See the notes to Table S.6a for further details on the construction and sources of data used.

Table S.11: Effects of sanctions on Iran's sectoral output growths estimated over the period 1989–2019

| | (1) | | | (2) | | | (3) | | | (4) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\Delta agr_t$ | $\Delta mfg_t$ | $\Delta svcs_t$ | $\Delta agr_t$ | $\Delta mfg_t$ | $\Delta svcs_t$ | $\Delta agr_t$ | $\Delta mfg_t$ | $\Delta svcs_t$ | $\Delta agr_t$ | $\Delta mfg_t$ | $\Delta svcs_t$ |
| $s_t$ | -0.010 | -0.154*** | -0.074*** | -0.008 | -0.158*** | -0.076*** | 0.019 | -0.143*** | -0.067*** | 0.038 | -0.154*** | -0.075*** |
| | (0.058) | (0.057) | (0.028) | (0.051) | (0.054) | (0.025) | (0.050) | (0.055) | (0.025) | (0.054) | (0.059) | (0.027) |
| $\Delta agr_{t-1}$ | 0.034 | -0.352* | -0.074 | 0.113 | -0.284 | -0.034 | 0.189 | -0.242 | -0.009 | 0.231 | -0.284 | -0.028 |
| | (0.189) | (0.188) | (0.092) | (0.169) | (0.180) | (0.083) | (0.164) | (0.182) | (0.083) | (0.162) | (0.177) | (0.082) |
| $\Delta mfg_{t-1}$ | 0.086 | -0.215 | -0.226** | -0.111 | -0.335* | -0.314*** | -0.106 | -0.332* | -0.313*** | -0.104 | -0.291 | -0.307*** |
| | (0.187) | (0.186) | (0.091) | (0.178) | (0.189) | (0.087) | (0.167) | (0.186) | (0.084) | (0.173) | (0.190) | (0.087) |
| $\Delta svcs_{t-1}$ | -0.048 | 1.271*** | 0.878*** | -0.084 | 1.235*** | 0.866*** | -0.244 | 1.145*** | 0.812*** | -0.348 | 1.238*** | 0.858*** |
| | (0.302) | (0.300) | (0.147) | (0.266) | (0.283) | (0.130) | (0.262) | (0.292) | (0.132) | (0.270) | (0.296) | (0.136) |
| $\Delta p_t^0$ | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| $grv_t$ | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| $\Delta \bar{r}_{wt}$ | | | | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| $\Delta \bar{e}_{wt}$ | | | | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| $\Delta \overline{req}_{wt}$ | | | | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| $\Delta \bar{y}_{wt}$ | | | | | | | yes | yes | yes | yes | yes | yes |
| $\Delta \bar{y}_t^0$ | | | | | | | | | | yes | yes | yes |
| $\Delta y_t^{Tur}$ | | | | | | | | | | yes | yes | yes |
| Adjusted $R^2$ | -0.020 | 0.385 | 0.545 | 0.102 | 0.378 | 0.598 | 0.167 | 0.368 | 0.601 | 0.133 | 0.365 | 0.585 |

**Notes**: $\Delta agr_t$, $\Delta mfg_t$, and $\Delta svcs_t$ are the yearly rates of change of the value added of agriculture, manufacturing and mining, and the services sector, respectively: $\Delta agr_t = \ln(Agr_t/Agr_{t-1}), \Delta mfg_t = \ln(Mfg_t/Mfg_{t-1})$, $\Delta svcs_t = \ln(Svcs_t/Svcs_{t-1})$, with $Agr_t, Mfg_t, Svcs_t$ being the value added of the three sectors aforementioned in year $t$. See the notes to Table S.6a for further details on the construction and sources of data used.

Table S.12: Effects of sanctions on the rate of change of value added of the agriculture and manufacturing sectors as a share of total value added over the period 1989–2019

| | (1) | | (2) | | (3) | | (4) | | (5) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $\Delta\widetilde{agr}_t$ | $\Delta\widetilde{mfg}_t$ | $\Delta\widetilde{agr}_t$ | $\Delta\widetilde{mfg}_t$ | $\Delta\widetilde{agr}_t$ | $\Delta\widetilde{mfg}_t$ | $\Delta\widetilde{agr}_t$ | $\Delta\widetilde{mfg}_t$ | $\Delta\widetilde{agr}_t$ | $\Delta\widetilde{mfg}_t$ |
| $s_t$ | 0.105* | -0.066* | 0.123** | -0.074** | 0.125** | -0.070** | 0.144*** | -0.076** | 0.122** | -0.063* |
| | (0.057) | (0.035) | (0.054) | (0.035) | (0.054) | (0.034) | (0.055) | (0.035) | (0.056) | (0.037) |
| $\Delta\widetilde{agr}_{t-1}$ | 0.598*** | -0.326*** | 0.662*** | -0.352*** | 0.671*** | -0.341*** | 0.715*** | -0.364*** | 0.596*** | -0.274** |
| | (0.188) | (0.115) | (0.178) | (0.114) | (0.178) | (0.112) | (0.175) | (0.111) | (0.185) | (0.122) |
| $\Delta\widetilde{mfg}_{t-1}$ | 0.708** | -0.176 | 0.711*** | -0.177 | 0.698*** | -0.193 | 0.748*** | -0.197 | 0.608** | -0.165 |
| | (0.289) | (0.178) | (0.271) | (0.173) | (0.270) | (0.171) | (0.266) | (0.169) | (0.272) | (0.179) |
| $\Delta\bar{y}_{wt}$ | | | yes | yes | yes | yes | yes | yes | yes | yes |
| $\Delta p_t^0$ | | | | | yes | yes | yes | yes | yes | yes |
| $\Delta\bar{y}_t^0$ | | | | | | | yes | yes | yes | yes |
| $\Delta y_t^{Tur}$ | | | | | | | yes | yes | yes | yes |
| $grv_t$ | | | | | | | | | yes | yes |
| $\Delta\bar{r}_{wt}$ | | | | | | | | | yes | yes |
| $\Delta\bar{e}_{wt}$ | | | | | | | | | yes | yes |
| $\Delta\overline{req}_{wt}$ | | | | | | | | | yes | yes |
| Adjusted $R^2$ | 0.182 | 0.147 | 0.256 | 0.162 | 0.235 | 0.159 | 0.218 | 0.139 | 0.207 | 0.048 |

**Notes**: $\Delta\widetilde{agr}_t$ and $\Delta\widetilde{mfg}_t$ are the yearly rates of change of the value added of the agriculture, and manufacturing and mining sectors as a fraction of total value added, respectively: $\Delta\widetilde{agr}_t = \ln(\widetilde{Agr}_t/\widetilde{Agr}_{t-1}), \Delta\widetilde{mfg}_t = \ln(\widetilde{Mfg}_t/\widetilde{Mfg}_{t-1})$, with $\widetilde{Agr}_t, \widetilde{Mfg}_t$, being the value added of the two sectors aforementioned divided by the sum of agriculture, manufacturing and mining and services value added in year $t$. See the notes to Table S.6a for further details on the construction and sources of data used.

Table S.13: Effects of sanctions on the rate of change of value added of the agriculture and services sectors as a share of total value added over the period 1989–2019

| | (1) | | (2) | | (3) | | (4) | | (5) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $\Delta\widetilde{agr}_t$ | $\Delta\widetilde{svcs}_t$ | $\Delta\widetilde{agr}_t$ | $\Delta\widetilde{svcs}_t$ | $\Delta\widetilde{agr}_t$ | $\Delta\widetilde{svcs}_t$ | $\Delta\widetilde{agr}_t$ | $\Delta\widetilde{svcs}_t$ | $\Delta\widetilde{agr}_t$ | $\Delta\widetilde{svcs}_t$ |
| $s_t$ | 0.111* | 0.017 | 0.125** | 0.018 | 0.129** | 0.016 | 0.152*** | 0.016 | 0.130** | 0.014 |
| | (0.058) | (0.012) | (0.055) | (0.012) | (0.055) | (0.012) | (0.055) | (0.012) | (0.057) | (0.013) |
| $\Delta\widetilde{agr}_{t-1}$ | 0.387** | 0.077** | 0.443*** | 0.082** | 0.459*** | 0.075** | 0.492*** | 0.080** | 0.423*** | 0.064* |
| | (0.157) | (0.033) | (0.151) | (0.034) | (0.151) | (0.033) | (0.148) | (0.033) | (0.161) | (0.038) |
| $\Delta\widetilde{svcs}_{t-1}$ | -1.703** | 0.084 | -1.633** | 0.090 | -1.612** | 0.081 | -1.794*** | 0.092 | -1.488** | 0.085 |
| | (0.680) | (0.144) | (0.644) | (0.143) | (0.639) | (0.139) | (0.631) | (0.139) | (0.638) | (0.151) |
| $\Delta\bar{y}_{wt}$ | | | yes | yes | yes | yes | yes | yes | yes | yes |
| $\Delta p_t^0$ | | | | | yes | yes | yes | yes | yes | yes |
| $\Delta\bar{y}_t^0$ | | | | | | | yes | yes | yes | yes |
| $\Delta y_t^{Tur}$ | | | | | | | yes | yes | yes | yes |
| $grv_t$ | | | | | | | | | yes | yes |
| $\Delta\bar{r}_{wt}$ | | | | | | | | | yes | yes |
| $\Delta\bar{e}_{wt}$ | | | | | | | | | yes | yes |
| $\Delta\overline{req}_{wt}$ | | | | | | | | | yes | yes |
| Adjusted $R^2$ | 0.188 | 0.101 | 0.247 | 0.085 | 0.228 | 0.103 | 0.222 | 0.070 | 0.216 | -0.076 |

**Notes**: $\Delta\widetilde{agr}_t$ and $\Delta\widetilde{svcs}_t$ are the rates of change of the value added of the agriculture and services sectors as a fraction of total value added, respectively: $\Delta\widetilde{agr}_t = \ln(\widetilde{Agr}_t/\widetilde{Agr}_{t-1}), \Delta\widetilde{svcs}_t = \ln(\widetilde{Svcs}_t/\widetilde{Svcs}_{t-1})$, with $\widetilde{Agr}_t, \widetilde{Svcs}_t$, being the value added of the two sectors aforementioned divided by the sum of agriculture, manufacturing and mining and services value added in year $t$. See the notes to Table S.6a for further details on the construction and sources of data used.

Table S.14: Effects of sanctions on the rate of change of value added of manufacturing and services sectors as a share of total value added over the period 1989–2019

| | (1) | | (2) | | (3) | | (4) | | (5) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $\Delta\widetilde{mfg}_t$ | $\Delta\widetilde{svcs}_t$ | $\Delta\widetilde{mfg}_t$ | $\Delta\widetilde{svcs}_t$ | $\Delta\widetilde{mfg}_t$ | $\Delta\widetilde{svcs}_t$ | $\Delta\widetilde{mfg}_t$ | $\Delta\widetilde{svcs}_t$ | $\Delta\widetilde{mfg}_t$ | $\Delta\widetilde{svcs}_t$ |
| $s_t$ | -0.072** | 0.018 | -0.075** | 0.018 | -0.072** | 0.017 | -0.082** | 0.017 | -0.067* | 0.014 |
| | (0.036) | (0.012) | (0.036) | (0.012) | (0.036) | (0.012) | (0.036) | (0.013) | (0.039) | (0.014) |
| $\Delta\widetilde{mfg}_{t-1}$ | 0.859*** | -0.241** | 0.881*** | -0.245** | 0.824*** | -0.218** | 0.945*** | -0.242** | 0.698* | -0.183 |
| | (0.306) | (0.105) | (0.304) | (0.105) | (0.307) | (0.105) | (0.304) | (0.106) | (0.357) | (0.127) |
| $\Delta\widetilde{svcs}_{t-1}$ | 2.436*** | -0.474 | 2.460*** | -0.479 | 2.343*** | -0.421 | 2.686*** | -0.473 | 2.007** | -0.337 |
| | (0.863) | (0.296) | (0.852) | (0.295) | (0.853) | (0.292) | (0.853) | (0.296) | (0.963) | (0.343) |
| $\Delta\bar{y}_{wt}$ | | | yes | yes | yes | yes | yes | yes | yes | yes |
| $\Delta p_t^0$ | | | | | yes | yes | yes | yes | yes | yes |
| $\Delta\bar{y}_t^0$ | | | | | | | yes | yes | yes | yes |
| $\Delta y_t^{Tur}$ | | | | | | | yes | yes | yes | yes |
| $grv_t$ | | | | | | | | | yes | yes |
| $\Delta\bar{r}_{wt}$ | | | | | | | | | yes | yes |
| $\Delta\bar{e}_{wt}$ | | | | | | | | | yes | yes |
| $\Delta\overline{req}_{wt}$ | | | | | | | | | yes | yes |
| Adjusted $R^2$ | 0.147 | 0.098 | 0.136 | 0.071 | 0.123 | 0.080 | 0.121 | 0.051 | 0.029 | -0.101 |

**Notes**: $\Delta\widetilde{mfg}_t$ and $\Delta\widetilde{svcs}_t$ are the rates of change of the value added of the manufacturing and mining, and services sectors as a fraction of total value added, respectively: $\Delta\widetilde{mfg}_t = \ln(\widetilde{Mfg}_t/\widetilde{Mfg}_{t-1}), \Delta\widetilde{svcs}_t = \ln(\widetilde{Svcs}_t/\widetilde{Svcs}_{t-1})$, with $\widetilde{Mfg}_t, \widetilde{Svcs}_t$, being the value added of the two sectors aforementioned divided by the sum of agriculture, manufacturing and mining and services value added in year $t$. See the notes to Table S.6a for further details on the construction and sources of data used.

Table S.15: Effects of sanctions on the rate of change of employment rate in Iran relative to other MENA countries estimated over the period 1995–2019

| | $\Delta\tilde{e}_t$ | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| $s_t$ | $-0.067^{**}$ | $-0.061^{**}$ | $-0.057^{*}$ | $-0.055^{*}$ | $-0.054^{*}$ |
| | (0.028) | (0.027) | (0.028) | (0.029) | (0.026) |
| $\Delta\tilde{e}_{t-1}$ | $0.408^{**}$ | $0.443^{**}$ | $0.439^{**}$ | $0.420^{**}$ | $0.373^{**}$ |
| | (0.180) | (0.176) | (0.177) | (0.184) | (0.168) |
| $\Delta y_t$ | $-0.170$ | $-0.119$ | $-0.081$ | $-0.087$ | $-0.103$ |
| | (0.111) | (0.112) | (0.123) | (0.125) | (0.114) |
| $\Delta p_t^0$ | | $-0.022$ | $-0.013$ | $-0.011$ | $-0.002$ |
| | | (0.014) | (0.017) | (0.019) | (0.017) |
| $\Delta\bar{y}_{wt}$ | | | $-0.297$ | $-0.079$ | $-0.536$ |
| | | | (0.368) | (0.554) | (0.542) |
| $\Delta\bar{y}_t^0$ | | | | $-0.217$ | $-0.335$ |
| | | | | (0.408) | (0.373) |
| $\Delta y_t^{Tur}$ | | | | | $0.235^{**}$ |
| | | | | | (0.106) |
| Adjusted $R^2$ | 0.236 | 0.287 | 0.274 | 0.245 | 0.381 |

**Notes**: The dependent variable is the rate of change of yearly employment rate in Iran relative to that of other MENA countries, namely $\Delta\tilde{e}_t = \Delta e_t - \Delta e_t^{MENA}$, where $\Delta e_t = \ln(E_t/E_{t-1})$ and $\Delta e_t^{MENA} = \ln(E_t^{MENA}/E_{t-1}^{MENA})$. $E_t$ is Iran's employment rate in year $t$, $E_t^{MENA} = \sum_{j=1}^{n_{MENA}} w_j E_{jt}$, where $\{E_{jt}\}_{j=1}^{n_{MENA}}$ are the employment rates of 17 MENA countries (excluding Iran) in year $t$, and $w_j$ the population weights for each country. See the notes to Table S.6a for further details on the construction and sources of data used. See Section S.2.3 in the data appendix of the online supplement for details on labor statistics.

Table S.16: Effects of sanctions on the rate of change of male labor force participation in Iran relative to other MENA countries estimated over the period 1995–2019

| | $\Delta\widetilde{lf}_{mt}$ | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| $s_t$ | $-0.034^{**}$ | $-0.028^{**}$ | $-0.026^{*}$ | $-0.025^{*}$ | $-0.024^{*}$ |
| | (0.015) | (0.013) | (0.013) | (0.013) | (0.013) |
| $\Delta\widetilde{lf}_{m,t-1}$ | $0.522^{***}$ | $0.557^{***}$ | $0.554^{***}$ | $0.535^{***}$ | $0.512^{***}$ |
| | (0.170) | (0.141) | (0.140) | (0.145) | (0.143) |
| $\Delta y_t$ | $-0.106^{*}$ | $-0.057$ | $-0.034$ | $-0.037$ | $-0.041$ |
| | (0.061) | (0.053) | (0.057) | (0.058) | (0.057) |
| $\Delta p_t^0$ | | $-0.021^{***}$ | $-0.016^{*}$ | $-0.014$ | $-0.012$ |
| | | (0.006) | (0.008) | (0.008) | (0.008) |
| $\Delta\bar{y}_{wt}$ | | | $-0.178$ | $-0.049$ | $-0.183$ |
| | | | (0.169) | (0.253) | (0.268) |
| $\Delta\bar{y}_t^0$ | | | | $-0.129$ | $-0.163$ |
| | | | | (0.185) | (0.184) |
| $\Delta y_t^{Tur}$ | | | | | 0.069 |
| | | | | | (0.052) |
| Adjusted $R^2$ | 0.299 | 0.520 | 0.523 | 0.510 | 0.529 |

**Notes**: The dependent variable is the rate of change of yearly male labor force participation rate in Iran relative to that of other MENA countries, namely $\Delta\widetilde{lf}_{mt} = \Delta lf_{mt} - \Delta lf_{mt}^{MENA}$, where $\Delta lf_{mt} = \ln(LF_{mt}/LF_{m,t-1})$ and $\Delta lf_{mt}^{MENA} = \ln(LF_{mt}^{MENA}/LF_{m,t-1}^{MENA})$. $LF_{mt}$ is Iran's male labor force participation rate in year $t$, $LF_{mt}^{MENA} = \sum_{j=1}^{n_{MENA}} w_j LF_{jmt}$, where $\{LF_{jmt}\}_{j=1}^{n_{MENA}}$ are the male labor force participation rates of 17 MENA countries (excluding Iran) in year $t$, and $w_j$ the population weights for each country. See the notes to Table S.6a for further details on the construction and sources of data used. See Section S.2.3 in the data appendix of the online supplement for details on labor statistics.

Table S.17: Effects of sanctions on the rate of change of female labor force participation in Iran relative to other MENA countries estimated over the period 1995–2019

| | $\Delta\widetilde{lf}_{ft}$ | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| $s_t$ | $-0.269^{***}$ | $-0.238^{***}$ | $-0.232^{***}$ | $-0.229^{***}$ | $-0.229^{***}$ |
| | (0.062) | (0.048) | (0.049) | (0.050) | (0.046) |
| $\Delta\widetilde{lf}_{f,t-1}$ | $0.535^{***}$ | $0.624^{***}$ | $0.617^{***}$ | $0.607^{***}$ | $0.588^{***}$ |
| | (0.143) | (0.111) | (0.112) | (0.116) | (0.107) |
| $\Delta y_t$ | $-0.583^{**}$ | $-0.393^{*}$ | $-0.327$ | $-0.332$ | $-0.353$ |
| | (0.256) | (0.201) | (0.220) | (0.225) | (0.207) |
| $\Delta p_t^0$ | | $-0.098^{***}$ | $-0.084^{**}$ | $-0.079^{**}$ | $-0.065^{*}$ |
| | | (0.024) | (0.031) | (0.033) | (0.031) |
| $\Delta\bar{y}_{wt}$ | | | $-0.491$ | $-0.150$ | $-0.920$ |
| | | | (0.641) | (0.960) | (0.957) |
| $\Delta\bar{y}_t^0$ | | | | $-0.344$ | $-0.525$ |
| | | | | (0.708) | (0.656) |
| $\Delta y_t^{Tur}$ | | | | | $0.387^{*}$ |
| | | | | | (0.186) |
| Adjusted $R^2$ | 0.602 | 0.770 | 0.765 | 0.755 | 0.793 |

**Notes**: The dependent variable is the rate of change of yearly female labor force participation rate in Iran relative to that of other MENA countries, namely $\Delta\widetilde{lf}_{ft} = \Delta lf_{ft} - \Delta lf_{ft}^{MENA}$, where $\Delta lf_{ft} = \ln(LF_{ft}/LF_{f,t-1})$ and $\Delta lf_{ft}^{MENA} = \ln(LF_{ft}^{MENA}/LF_{f,t-1}^{MENA})$. $LF_{ft}$ is Iran's female labor force participation rate in year $t$, $LF_{ft}^{MENA} = \sum_{j=1}^{n_{MENA}} w_j LF_{jft}$, where $\{LF_{jft}\}_{j=1}^{n_{MENA}}$ are the female labor force participation rates of 17 MENA countries (excluding Iran) in year $t$, and $w_j$ the population weights for each country. See the notes to Table S.6a for further details on the construction and sources of data used. See Section S.2.3 in the data appendix of the online supplement for details on labor statistics.

Table S.18: Effects of sanctions on the rate of change of labor force participation in Iran relative to other MENA countries estimated over the period 1995–2019

| | $\Delta\widetilde{lf}_t$ | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| $s_t$ | $-0.077^{***}$ | $-0.067^{***}$ | $-0.064^{***}$ | $-0.062^{***}$ | $-0.062^{***}$ |
| | (0.023) | (0.018) | (0.018) | (0.019) | (0.018) |
| $\Delta\widetilde{lf}_{t-1}$ | $0.557^{***}$ | $0.620^{***}$ | $0.613^{***}$ | $0.598^{***}$ | $0.568^{***}$ |
| | (0.153) | (0.123) | (0.122) | (0.127) | (0.119) |
| $\Delta y_t$ | $-0.193^{**}$ | $-0.121$ | $-0.084$ | $-0.087$ | $-0.093$ |
| | (0.093) | (0.076) | (0.082) | (0.083) | (0.078) |
| $\Delta p_t^0$ | | $-0.034^{***}$ | $-0.026^{**}$ | $-0.024^{*}$ | $-0.019$ |
| | | (0.009) | (0.011) | (0.012) | (0.012) |
| $\Delta\bar{y}_{wt}$ | | | $-0.278$ | $-0.121$ | $-0.386$ |
| | | | (0.240) | (0.360) | (0.363) |
| $\Delta\bar{y}_t^0$ | | | | $-0.157$ | $-0.226$ |
| | | | | (0.266) | (0.250) |
| $\Delta y_t^{Tur}$ | | | | | $0.136^{*}$ |
| | | | | | (0.071) |
| Adjusted $R^2$ | 0.472 | 0.668 | 0.673 | 0.662 | 0.706 |

**Notes**: The dependent variable is the difference between the rate of change of yearly labor force participation rate in Iran and other MENA countries: $\Delta\widetilde{lf}_t = \Delta lf_t - \Delta lf_t^{MENA}$, with $\Delta lf_t = \ln(LF_t/LF_{t-1})$ and $\Delta lf_t^{MENA} = \ln(LF_t^{MENA}/LF_{t-1}^{MENA})$. $LF_t$ is Iran's labor force participation rate in year $t$, $LF_t^{MENA} = \sum_{j=1}^{n_{MENA}} w_j LF_{jt}$, with $\{LF_{jt}\}_{j=1}^{n_{MENA}}$ being the labor force participation rate of 17 MENA countries (Iran not included) in year $t$, and $w_j$ the population weights for each country. See the notes to Table S.6a for further details on the construction and sources of data used. See Section S.2.3 in the data appendix of the online supplement for details on labor statistics.

Table S.19: Effects of sanctions on the rate of change of the number of lower secondary schools in Iran estimated over the period 1989–2018

| | Lower secondary schools | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| $s_{t-1}$ | $-0.217^{***}$ | $-0.221^{***}$ | $-0.227^{***}$ | $-0.222^{***}$ | $-0.223^{***}$ |
| | (0.052) | (0.052) | (0.050) | (0.054) | (0.055) |
| $\Delta y_t$ | 0.124 | 0.166 | 0.130 | 0.117 | 0.114 |
| | (0.167) | (0.167) | (0.163) | (0.172) | (0.181) |
| $\Delta p_t^0$ | | $-0.036$ | $-0.066^{**}$ | $-0.062^{*}$ | $-0.062$ |
| | | (0.027) | (0.032) | (0.035) | (0.036) |
| $\Delta \bar{y}_{wt}$ | | | 1.072 | 1.288 | 1.265 |
| | | | (0.637) | (0.979) | (1.068) |
| $\Delta \bar{y}_t^0$ | | | | $-0.233$ | $-0.233$ |
| | | | | (0.791) | (0.808) |
| $\Delta y_t^{Tur}$ | | | | | 0.011 |
| | | | | | (0.186) |
| Adjusted $R^2$ | 0.413 | 0.429 | 0.467 | 0.447 | 0.423 |

**Notes**: The dependent variable is the rate of change of the number of lower secondary schools in Iran. See the notes to Table S.6a for further details on the construction and sources of data used. See Section S.2.3 in the data appendix of the online supplement for details on education statistics.

Table S.20: Effects of sanctions on the rate of change of the number of high schools in Iran estimated over the period 1989–2018

| | High schools | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| $s_{t-1}$ | $-0.253^{***}$ | $-0.248^{***}$ | $-0.254^{***}$ | $-0.272^{***}$ | $-0.266^{***}$ |
| | (0.074) | (0.075) | (0.075) | (0.080) | (0.081) |
| $\Delta y_t$ | 0.031 | $-0.010$ | $-0.044$ | 0.004 | 0.047 |
| | (0.238) | (0.243) | (0.244) | (0.256) | (0.266) |
| $\Delta p_t^0$ | | 0.035 | 0.006 | $-0.010$ | $-0.012$ |
| | | (0.039) | (0.047) | (0.053) | (0.053) |
| $\Delta \bar{y}_{wt}$ | | | 1.025 | 0.256 | 0.647 |
| | | | (0.955) | (1.456) | (1.571) |
| $\Delta \bar{y}_t^0$ | | | | 0.830 | 0.842 |
| | | | | (1.177) | (1.189) |
| $\Delta y_t^{Tur}$ | | | | | $-0.195$ |
| | | | | | (0.274) |
| Adjusted $R^2$ | 0.281 | 0.275 | 0.280 | 0.265 | 0.249 |

**Notes**: The dependent variable is the rate of change of the number of high schools in Iran. See the notes to Table S.6a for further details on the construction and sources of data used. See Section S.2.3 in the data appendix of the online supplement for details on education statistics.

Table S.21: Effects of sanctions on the rate of change of the number of primary schools in Iran estimated over the period 1989–2018

| | Primary schools | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| $s_{t-1}$ | −0.041 | −0.041 | −0.040 | −0.047 | −0.051 |
| | (0.033) | (0.034) | (0.034) | (0.037) | (0.037) |
| $\Delta y_t$ | 0.040 | 0.040 | 0.045 | 0.064 | 0.037 |
| | (0.105) | (0.109) | (0.112) | (0.118) | (0.121) |
| $\Delta p_t^0$ | | −0.001 | 0.003 | −0.003 | −0.002 |
| | | (0.018) | (0.022) | (0.024) | (0.024) |
| $\Delta \bar{y}_{wt}$ | | | −0.130 | −0.441 | −0.686 |
| | | | (0.438) | (0.669) | (0.715) |
| $\Delta \bar{y}_t^0$ | | | | 0.336 | 0.329 |
| | | | | (0.541) | (0.542) |
| $\Delta y_t^{Tur}$ | | | | | 0.122 |
| | | | | | (0.125) |
| Adjusted $R^2$ | 0.007 | −0.031 | −0.068 | −0.095 | −0.097 |

**Notes**: The dependent variable is the rate of change of the number of primary schools in Iran. See the notes to Table S.6a for further details on the construction and sources of data used. See Section S.2.3 in the data appendix of the online supplement for details on education statistics.

Table S.22: Effects of sanctions on the number of female to male students across all grades (rate of change) estimated over the period 1989–2019

| | Female-to-male student ratio | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| $s_t$ | $-0.028^{***}$ | $-0.028^{***}$ | $-0.028^{***}$ | $-0.028^{***}$ | $-0.028^{***}$ |
| | (0.008) | (0.008) | (0.008) | (0.008) | (0.009) |
| $\Delta y_t$ | 0.005 | 0.004 | 0.003 | −0.0001 | −0.004 |
| | (0.027) | (0.029) | (0.029) | (0.031) | (0.032) |
| $\Delta p_t^0$ | | 0.001 | −0.001 | 0.0002 | 0.0005 |
| | | (0.005) | (0.006) | (0.006) | (0.006) |
| $\Delta \bar{y}_{wt}$ | | | 0.042 | 0.093 | 0.063 |
| | | | (0.111) | (0.170) | (0.184) |
| $\Delta \bar{y}_t^0$ | | | | −0.052 | −0.054 |
| | | | | (0.130) | (0.132) |
| $\Delta y_t^{Tur}$ | | | | | 0.015 |
| | | | | | (0.033) |
| Adjusted $R^2$ | 0.358 | 0.335 | 0.313 | 0.290 | 0.267 |

**Notes**: The dependent variable is the rate of change of the ratio of Iran's females students (as a proportion of the Iran's female population ages 5–19) to the males students (as a proportion of the Iran's male population ages 5–19). See the notes to Table S.6a for further details on the construction and sources of data used. See Section S.2.3 in the data appendix of the online supplement for details on education statistics.

Table S.23: Effects of sanctions on the rate of change of the number of primary school teachers in Iran estimated over the period 1989–2019

| | Primary school teachers | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| $s_{t-1}$ | 0.026 | 0.025 | 0.024 | −0.005 | −0.013 |
| | (0.069) | (0.070) | (0.071) | (0.071) | (0.072) |
| $\Delta y_t$ | 0.186 | 0.195 | 0.181 | 0.252 | 0.205 |
| | (0.217) | (0.225) | (0.232) | (0.229) | (0.236) |
| $\Delta p_t^0$ | | −0.008 | −0.017 | −0.047 | −0.045 |
| | | (0.038) | (0.047) | (0.049) | (0.049) |
| $\Delta \bar{y}_{wt}$ | | | 0.323 | −1.350 | −1.814 |
| | | | (0.934) | (1.368) | (1.471) |
| $\Delta \bar{y}_t^0$ | | | | 1.744 | 1.743 |
| | | | | (1.069) | (1.073) |
| $\Delta y_t^{Tur}$ | | | | | 0.228 |
| | | | | | (0.258) |
| Adjusted $R^2$ | −0.044 | −0.081 | −0.117 | −0.050 | −0.059 |

**Notes**: The dependent variable is the rate of change of the number of primary school teachers in Iran as a proportion of the Iran 25–64 population. See the notes to Table S.6a for further details on the construction and sources of data used. See Section S.2.3 in the data appendix of the online supplement for education statistics.

Table S.24: Effects of sanctions on the rate of change of the number of lower secondary school teachers in Iran estimated over the period 1989–2019

| | Lower secondary school teachers | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| $s_{t-1}$ | −0.222*** | −0.228*** | −0.233*** | −0.221*** | −0.229*** |
| | (0.069) | (0.068) | (0.065) | (0.068) | (0.069) |
| $\Delta y_t$ | 0.054 | 0.114 | 0.047 | 0.019 | −0.023 |
| | (0.218) | (0.218) | (0.212) | (0.219) | (0.226) |
| $\Delta p_t^0$ | | −0.052 | −0.096** | −0.084* | −0.082* |
| | | (0.037) | (0.043) | (0.047) | (0.047) |
| $\Delta \bar{y}_{wt}$ | | | 1.545* | 2.215 | 1.801 |
| | | | (0.856) | (1.306) | (1.407) |
| $\Delta \bar{y}_t^0$ | | | | −0.699 | −0.700 |
| | | | | (1.020) | (1.027) |
| $\Delta y_t^{Tur}$ | | | | | 0.203 |
| | | | | | (0.247) |
| Adjusted $R^2$ | 0.286 | 0.312 | 0.365 | 0.352 | 0.344 |

**Notes**: The dependent variable is the rate of change of the number of lower secondary school teachers in Iran as a proportion of the Iran 25–64 population. See the notes to Table S.6a for further details on the construction and sources of data used. See Section S.2.3 in the data appendix of the online supplement for education statistics.

Table S.25: Effects of sanctions on the rate of change of the number of high school teachers in Iran estimated over the period 1989–2019

| | High school teachers | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| $s_{t-1}$ | $-0.170^{**}$ | $-0.163^{*}$ | $-0.164^{*}$ | $-0.190^{**}$ | $-0.185^{**}$ |
| | (0.081) | (0.081) | (0.082) | (0.084) | (0.086) |
| $\Delta y_t$ | 0.185 | 0.121 | 0.106 | 0.170 | 0.199 |
| | (0.257) | (0.259) | (0.267) | (0.269) | (0.281) |
| $\Delta p_t^0$ | | 0.056 | 0.047 | 0.019 | 0.018 |
| | | (0.044) | (0.054) | (0.057) | (0.058) |
| $\Delta \bar{y}_{wt}$ | | | 0.337 | $-1.189$ | $-0.912$ |
| | | | (1.077) | (1.608) | (1.751) |
| $\Delta \bar{y}_t^0$ | | | | 1.591 | 1.592 |
| | | | | (1.257) | (1.277) |
| $\Delta y_t^{Tur}$ | | | | | $-0.136$ |
| | | | | | (0.307) |
| Adjusted $R^2$ | 0.163 | 0.182 | 0.154 | 0.173 | 0.145 |

**Notes**: The dependent variable is the rate of change of the number of high school teachers in Iran as a proportion of the Iran 25–64 population. See the notes to Table S.6a for further details on the construction and sources of data used. See Section S.2.3 in the data appendix of the online supplement for education statistics.

Table S.26: Effects of sanctions on the rate of change of the total number of teachers in Iran estimated over the period 1989–2019

| | Total number of teachers | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| $s_{t-1}$ | $-0.089$ | $-0.089$ | $-0.090$ | $-0.108^{*}$ | $-0.112^{*}$ |
| | (0.054) | (0.056) | (0.056) | (0.057) | (0.058) |
| $\Delta y_t$ | 0.163 | 0.158 | 0.133 | 0.177 | 0.154 |
| | (0.172) | (0.178) | (0.182) | (0.184) | (0.191) |
| $\Delta p_t^0$ | | 0.004 | $-0.013$ | $-0.031$ | $-0.030$ |
| | | (0.030) | (0.037) | (0.039) | (0.040) |
| $\Delta \bar{y}_{wt}$ | | | 0.575 | $-0.457$ | $-0.680$ |
| | | | (0.735) | (1.098) | (1.193) |
| $\Delta \bar{y}_t^0$ | | | | 1.077 | 1.076 |
| | | | | (0.858) | (0.870) |
| $\Delta y_t^{Tur}$ | | | | | 0.109 |
| | | | | | (0.209) |
| Adjusted $R^2$ | 0.124 | 0.093 | 0.079 | 0.099 | 0.072 |

**Notes**: The dependent variable is the rate of change of the total number of teachers in Iran. The total number of teachers is computed as the sum of primary, lower secondary, and high schools teachers, as a proportion of the 25–64 Iran population. See the notes to Table S.6a for further details on the construction and sources of data used. See Section S.2.3 in the data appendix of the online supplement for education statistics.

Table S.27: Effects of sanctions on the rate of change of the total number of schools in Iran estimated over the period 1989–2018

| | Total number of schools | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| $s_{t-1}$ | $-0.102^{***}$ | $-0.102^{***}$ | $-0.104^{***}$ | $-0.111^{***}$ | $-0.112^{***}$ |
| | (0.030) | (0.031) | (0.031) | (0.033) | (0.034) |
| $\Delta y_t$ | 0.059 | 0.056 | 0.047 | 0.065 | 0.055 |
| | (0.097) | (0.100) | (0.102) | (0.107) | (0.112) |
| $\Delta p_t^0$ | | 0.002 | −0.006 | −0.012 | −0.011 |
| | | (0.016) | (0.020) | (0.022) | (0.022) |
| $\Delta \bar{y}_{wt}$ | | | 0.280 | −0.019 | −0.115 |
| | | | (0.399) | (0.609) | (0.661) |
| $\Delta \bar{y}_t^0$ | | | | 0.323 | 0.320 |
| | | | | (0.492) | (0.501) |
| $\Delta y_t^{Tur}$ | | | | | 0.048 |
| | | | | | (0.115) |
| Adjusted $R^2$ | 0.307 | 0.281 | 0.266 | 0.249 | 0.222 |

**Notes**: The dependent variable is the rate of change of the total number of schools. The total number of schools is computed as the sum of primary, lower secondary, and high schools. See the notes to Table S.6a for further details on the construction and sources of data used. See Section S.2.3 in the data appendix of the online supplement for education statistics.

Table S.28: Chronology of major sanctions events against Iran over the period from November 1979 to January 2021

| Date | Event | Diplomatic measures | Direction | Sanctioning entity | Additional notes |
|---|---|---|---|---|---|
| Nov. 12, 1979 | "Tehran hostage crisis" | Oil embargo | On | U.S.A. | Proclamation 4702(1979) by U.S. President Carter |
| Nov. 14, 1979 | "Tehran hostage crisis" | Asset freeze of all Iranian government and Central Bank of Iran properties within U.S. jurisdiction | On | U.S.A. | U.S. Executive Order 12170 |
| Apr. 7, 1980 | "Tehran hostage crisis" | Sale and transportation of all goods to Iran forbidden. No credit and loans to Iran allowed | On | U.S.A. | U.S. Executive Order 12205 |
| Apr. 17, 1980 | "Tehran hostage crisis" | Ban on all imports from Iran. U.S. citizens prevented from traveling to Iran or conducting financial transactions in Iran | On | U.S.A. | U.S. Executive Order 12211 |
| Jan. 19, 1981 | Hostages release | Revocation of prohibitions against transactions involving Iran | Off | U.S.A. | U.S. Executive Order 12282 |
| Jan. 19, 1984 | 1983 U.S. embassy bombing in Beirut | Ineligibility for various forms of U.S. foreign assistance. Arms embargo. Imposition of miscellaneous financial restrictions | On | U.S.A. | "State Sponsor of Terror" designation |
| Oct. 29, 1987 | Support of international terrorism | No goods or services of Iranian origin allowed to be imported into the U.S.. Iranian oil refined in third countries allowed | On | U.S.A. | U.S. Executive Order 12613 |
| Oct. 23, 1992 | Iran-Iraq Arms Non-Proliferation Act | Measures to prevent transfer of goods or technology to Iraq or Iran to avoid acquisition of Weapons of Mass Destruction (*WMD)* | On | U.S.A. | U.S. Public Law 102-484 |
| Nov. 14, 1994 | Nuclear threat | Controls and restrictions on goods related to WMD technology | On | U.S.A. | U.S. Executive Order 12938 |
| Mar. 15, 1995 | Threat to national security | Ban U.S. investment in Iran's energy sector | On | U.S.A. | U.S. Executive Order 12957 |
| May 6, 1995 | Threat to national security | More comprehensive investment, trade, and financial restrictions | On | U.S.A. | U.S. Executive Order 12959 |
| Aug. 5, 1996 | Iran and Libya Sanctions Act (*ILSA*) | Two economic and/or financial sanctions (out of a list of 6) on U.S. and non-U.S. companies providing investments over $40 million in petroleum resources in Iran | On | U.S.A. | U.S. Public Law 104 - 172 |
| Nov. 22, 1996 | "Blocking regulation" following the U.S. ILSA | E.U. single member states encouraged to impose sanctions in compliance with the ILSA of 1996 | On | E.U. | Council Regulation 2271/96 |
| Aug. 19, 1997 | Nuclear threat | Trade sanctions previously in place largely expanded in scope | On | U.S.A. | U.S. Executive Order 13059 |

Table S.28: Chronology of major sanctions events against Iran over the period from November 1979 to January 2021

| Date | Event | Diplomatic measures | Direction | Sanctioning entity | Additional notes |
|---|---|---|---|---|---|
| Mar. 14, 2000 | Iran Nonproliferation Act | The President authorized to act against individuals or organizations known to provide material aid to WMD | On | U.S.A. | U.S. Public Law 106 -178 |
| Aug. 3, 2001 | ILSA Extension Act of 2001 | ILSA Renewed for 5 years. Extends the scope of previous sanctions. Max investments allowed from $40 to $20 millions | On | U.S.A. | U.S. Public Law 107-24 |
| Sep. 23, 2001 | Twin Towers attacks in New York City | Blocking property and prohibiting transactions with persons committing or supporting terrorism. Iranians marginally involved | On | U.S.A. | U.S. Executive Order 13224 |
| June 29, 2005 | Nuclear threat | Assets freeze of individual connected to Iran WMD proliferation and their supporters | On | U.S.A. | U.S. Executive Order 13382 |
| July 31, 2006 | Nuclear threat | Prohibits the transfer of any materials that could contribute to Iran's nuclear and ballistic missile programmes | On | U.N. | United Nations Security Council Resolution 1696 |
| Aug. 4, 2006 | ILSA Extension | The U.S. further extend ILSA until Sep. 29, 2006 | On | U.S.A. | U.S. Public Law 109-267 |
| Sep. 30, 2006 | Iran Freedom and Support Act (*IFSA*) | Secondary sanctions imposed. Oil-related investments banned. Support to "pro-democracy" groups opposed to Iran. | On | U.S.A. | U.S. Public Law 109-293 |
| Dec. 23, 2006 | Nuclear threat | Trade embargo on nuclear-related goods and technologies. Ban of financial support for nuclear projects. Assets freeze | On | U.S.A. | United Nations Security Council Resolution 1737 |
| Feb. 27, 2007 | Nuclear threat | Ban on export of nuclear technology, and financial assistance related to nuclear activities. Assets freeze and travel restrictions | On | E.U. | Council Common Position 2007/140/CFSP |
| Mar. 24, 2007 | Nuclear threat | Sanctions strengthened on individuals and arms related to the development of WMD | On | U.N. | United Nations Security Council Resolution 1747 |
| July 17, 2007 | Iraq War. Measures to increase isolation of Iraq | Assets freeze of people connected to Iraq War. Iranians marginally hit | On | U.S.A. | U.S. Executive Order 13438 |
| Mar. 3, 2008 | Nuclear threat | Ban on WMD technology transfers, financial restrictions, call to monitor Iranian institutions and individuals | On | U.N. | United Nations Security Council Resolution 1803 |
| Sep. 27, 2008 | Ongoing uranium-enrichment programs reported by IAEA | Re-affirm previous sanctions | On | U.N. | United Nations Security Council Resolution 1835 |
| June 9, 2010 | Nuclear threat | Restrictions related to ballistic programs and WMD technologies. Prohibits new banking relations | On | U.N. | United Nations Security Council Resolution 1929 |

Table S.28: Chronology of major sanctions events against Iran over the period from November 1979 to January 2021

| Date | Event | Diplomatic measures | Direction | Sanctioning entity | Additional notes |
|---|---|---|---|---|---|
| July 1, 2010 | Comprehensive Iran Sanctions, Accountability, and Divestment Act (*CISADA*) | Scope of previous sanctions expanded. Curb on import/export of petroleum. Extented FX, banking, and property transactions | On | U.S.A. | U.S. Public Law 111-195 |
| July 22, 2010 | Nuclear threat | Extra sanctions imposed by Canada (on top of the U.N. ones) under the "Special Economic Measures Act" -- SEMA | On | CAN | SOR/2010 - 165 |
| July 26, 2010 | Nuclear threat | U.N. 1929(2010) resolution embedded in the E.U. framework. Additional economic, banking and financial restrictions imposed | On | E.U. | Council Decision 2010/413/CFSP |
| Sep. 28, 2010 | Human rights violations | Assets freeze and limits to transfers and donations | On | U.S.A. | U.S. Executive Order 13553 |
| Apr. 12, 2011 | Human rights violation | Travel restrictions and assets freeze of people related to human rights violations | On | E.U. | Council Decision 2011/235/CFSP |
| Apr. 29, 2011 | Human rights violation | Assets freeze of persons and entities involved with abuses. Donations prohibited | On | U.S.A. | U.S. Executive Order 13572 |
| May 23, 2011 | Nuclear threat | Enhanced sanctions from Iran Sanctions Act (*ISA*). No credit, no FX, property block from U.S. financial institutions, imports ban | On | U.S.A. | U.S. Executive Order 13574 |
| June 9, 2011 | Nuclear threat | Extended mandate of the "panel of experts" that supports the Iran Sanctions Committee for one year. | On | U.N. | U.N. Security Council Resolution 1984 |
| Nov. 20, 2011 | Threat to national security | Sanctions on entities and individuals helping the Iran's energy and petrochemical sectors maintenance and expansion | On | U.S.A. | U.S. Executive Order 13590 |
| Dec. 31, 2011 | National Defence Authorization Act | Sanctions against banks dealing with Iranian financial institutions, Bank Markazi included. Restricted export of Iranian oil. | On | U.S.A. | U.S. NDAA 2012 - Sec. 1245 |
| Jan. 23, 2012 | Nuclear threat | Oil embargo, assets freeze of Central Bank of Iran (*CBI*). Embargo on gold, precious metals | On | E.U. | Council Decision 2012/35/CFSP |
| Feb. 5, 2012 | Anti-money laundering malpractice | Blocking property of the Government of Iran and Iranian financial institutions, Bank Markazi included | On | U.S.A. | U.S. Executive Order 13599 |
| Mar. 15, 2012 | Nuclear threat | Decision 2010/413/CFSP expanded with new but marginal financial restrictions | On | E.U. | Council Decision 2012/152/CFSP |

Table S.28: Chronology of major sanctions events against Iran over the period from November 1979 to January 2021

| Date | Event | Diplomatic measures | Direction | Sanctioning entity | Additional notes |
|---|---|---|---|---|---|
| Mar. 23, 2012 | Nuclear threat | Wide expansion of scope of import/export restrictions and banking and financial sanctions | On | E.U. | Council Regulation No. 267/2012 |
| Apr. 22, 2012 | Human right violations | Assets freeze of companies providing technology for human rights abuses. Donations prohibited to blocked entities and persons | On | U.S.A. | U.S. Executive Order 13606 |
| May 1, 2012 | Measures against sanctions evaders | Extra sanctions for entities and persons found to evade previously issued sanctions against Iran | On | U.S.A. | U.S. Executive Order 13608 |
| June 7, 2012 | Nuclear threat | Renewed the mandate of the Committee's Panel of Experts to monitor Iran for 13 months | On | U.N. | U.N. Security Council Resolution 2049 |
| July 30, 2012 | Threat to national security | Sanctions on foreign institutions involved in deals with Iran's energy and petrochemical sectors products. | On | U.S.A. | U.S. Executive Order 13622 |
| Aug. 10, 2012 | Iran Threat Reduction and Syria Human Rights Act | New multilateral sanctions on entities facilitating Iranian transactions (oil sector mostly); amends the ISA of 1996 | On | U.S.A. | U.S. Public Law 112-158 |
| Oct. 9, 2012 | Threat to national security | Expansion of assets freeze and financial restrictions | On | U.S.A. | U.S. Executive Order 13628 |
| Oct. 15, 2012 | Nuclear threat | Ban on trade and financial assistance to buy natural gas, a range of manufacturing and software products for ballistic missiles, and ship-building | On | E.U. | Council Decision 2012/635/CFSP |
| Jan. 2, 2013 | U.S. National Defense Authorization Act | Broad range of economic and financial sanctions expanded | On | U.S.A. | U.S. Public Law 112-239 |
| June 3, 2013 | Nuclear threat | Financial restrictions and assets freeze on foreign institutions doing business in rials or in automotive industry, among others | On | U.S.A. | U.S. Executive Order 13645 |
| July 20, 2015 | Joint Comprehensive Plan Of Action (*JCPOA*) | Agreement to schedule suspension and lift of U.N. sanctions | Off | U.N. | U.N. Security Council Resolution 2231 |
| Oct. 18, 2015 | JCPOA | E.U. intermediate steps towards application of JCPOA | Off | E.U. | Council Decision 2015/1863/CFSP |
| Jan. 16, 2016 | JCPOA | Implementiation day: The E.U., U.S., and U.N. suspend or terminate nuclear-related sanctions. A process of recovery of Iran's assets for about $100 billions begins (never fully implemented) | Off | U.N. | U.N. Security Council Resolution 2231 implementiation |
| Jan. 17, 2016 | SWIFT re-activation | Iranian banks access to the SWIFT system. U.S. banks remain prohibited from doing business with Iran directly or indirectly | Off | World | www.swift.com/insights/press-releases/update_iran-sanctions-agreement |

Table S.28: Chronology of major sanctions events against Iran over the period from November 1979 to January 2021

| Date | Event | Diplomatic measures | Direction | Sanctioning entity | Additional notes |
|---|---|---|---|---|---|
| Dec. 1, 2016 | U.S. renews ISA for 10 years | U.S. renew the sanctions going on since 1996 on Iran | On | U.S.A. | U.S. Congress Issue H.R. 6297, Vote n. 155 |
| May 8, 2018 | JCPOA reduction of scope | U.S. announcement of withdrawal from JCPOA | On | U.S.A. | en.wikipedia.org/wiki/United_States_withdrawal_from_the_Joint_Comprehensive_Plan_of_Action |
| Aug. 6, 2018 | U.S. "maximum pressure" | Re-impose all sanctions lifted or waived by JCPOA | On | U.S.A | U.S. Executive Order 13846 |
| Nov. 5, 2018 | U.S. "maximum pressure" | Largest ever single-day action targeting the Iranian regime. More than 700 individuals, entities, aircrafts and vessels hit | On | U.S.A. | U.S. Treasury Statement 541 of Nov. 5 2018 |
| Nov. 9, 2018 | Financial system stability and integrity protection | SWIFT restrictions | On | U.S.A. | www.swift.com/about-us/legal/compliance-0/swift-and-sanctions |
| May 8, 2019 | Threat to national security | Sanctions on iron, steel, aluminum, and copper sectors of Iran | On | U.S.A. | U.S. Executive Order 13871 |
| June 24, 2019 | Support of terrorist militias in the Middle East | Further assets freeze, secondary sanctions on financial institutions | On | U.S.A. | U.S. Executive Order 13876 |
| Jan. 10, 2020 | Support of terrorist militias in the Middle East | Assets freeze related to entities and individuals trading in the manufacturing sector, among others. Restrictions on immigrants | On | U.S.A. | U.S. Executive Order 13902 |
| Sep. 21, 2020 | Threat to national security | Sanctions related to the trade and financially support arms trade | On | U.S.A. | U.S. Executive Order 13949 |
| Oct. 8, 2020 | JCPOA withdrawal | 18 Iranian banks hit by further sanctions | On | U.S.A. | U.S. Treasury Statement 1147 of Oct. 8 2020 |
| Dec. 16, 2020 - Jan. 5, 2021 | Support of "destabilizing activities" in the Middle East | Sanctions on companies supporting: metal, steel, petroleum and petrochemical sectors | On | U.S.A. | U.S. Treasury Statements 1214, and 1226 |
| Jan. 13, 2021 | Entities designated pursuant to Executive Order 13876, | Sanctions on two organizations controlled by the Supreme Leader | On | U.S.A. | U.S. Treasury Statement 1234 of Jan. 13, 2021 |