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Abstract

Power sector reforms have been widely adopted in the turn of the 21st Century, including in the Middle East and North Africa. Have the promises that accompany such reforms led to technological change in the region? Adopting an instrumental variable approach and using an index of power sector reforms and aggregate macroeconomic data for 18 Arab League member states between 1982 and 2013, we provide robust evidence that there is a positive causal relationship between power sector reforms and technological change, proxied by high-tech exports, in Arab countries. While the literature has evidenced a relationship between such reforms and economic growth, our results suggest that technological change is a transmission channel of this relationship.

Keywords: Power Sector Reforms, Industrialization, Technological Change, Arab Countries.
JEL Classification: F14, L50, 014, O38.

1 Introduction

Countries from the Arab region have suffered for a long time from frequent power outages, poor power distribution throughout their territory, and increased loads on power generation networks. This, in turn, created related issues such as low-quality and expensive access to power. Accordingly, firms have suffered from increasing production costs and low productivity. Recently however, a majority of countries in the Arab region have adopted power sector reforms. Such reforms have provided promising opportunities to provide higher-quality and cheaper power so that firms can reduce their production costs and invest more in technological adoption and innovation. The availability of high-quality power is an incentive for firms to produce more sophisticated and high-tech intensive products.

In this context, the objective of this paper is to study the effect of power sector reforms on technological adoption in Arab countries. Have these reforms paved the way for technological change? Have countries gained from changes in the regulation of the power sector? Power sector reforms can reduce power outages and increase the efficiency of electricity distribution. Firms need electricity to optimize their machinery usage (e.g., production processes are less disrupted because of electricity outages) and such reforms encourage firms to use technologically more advanced products or processes which depend on telecom or internet/data connection. It is not reliable to produce high-tech products, which require very precise and advanced machines and ICT adoption, without having constant and strong power connection: Power outages simply can hinder the productivity of firms that adopt more sophisticated machines and technology, negatively impacting the production of high-tech products and their exports. Power sector reforms can allow for technological change by making the process of producing high-tech products easier.

To test this hypothesis, we rely on aggregate macroeconomic data and a dataset of power sector reforms for 18 Arab League member states[1] during the period spanning from 1982 to 2013. We first use an OLS approach to estimate the relationship of hybrid power sector reforms on high-tech exports. However, due to the likely presence of unobserved characteristics which might confound the effect of hybrid power sector reforms on high-tech exports, and due to reverse causality concerns, the OLS estimates might be biased.

The paper then follows three strategies to solve for these bias that affect OLS estimates. The first strategy is to mitigate the omitted variable bias by accounting for a wide set of covariates which might drive the results. Secondly, we use an instrumen-

[1]Power sector reform data are missing for four member states: Comoros, Mauritania, Palestine and Somalia.

tal variable approach to solve the endogeneity issue that arises from reverse causality. The instrumental variable relevence is ensured by the fact that the neighbours adopt similar institutional regulations and reforms to compete for and attract more investments, as evidenced by the literature. Moreover, we argue that there is no violation of the exclusion restriction because FDI is not a potential channel, as it is concentrated in specific sectors, other than the high-tech sector. Furthermore, there is no direct positive effect of the neighbouring countries power sector reforms on high-tech exports since intra-regional trade between Arab countries is very scarce. Finally, our third strategy is to use country and year fixed effects to account for unobservable time-invariant factors and unobservable common time-varying factors which might be associated with public procurement and high-tech exports.

This article makes three contributions to the existing literature. First, to the best of our knowledge, it is the first to study the relationship between power sector reforms and technological change, proxied by high-tech exports. There is an extensive literature that documents the direct effect of power sector reforms on electricity consumption as well as transmission and distribution losses (such as Parker and Kirkpatrick, 2002; Zhang et al., 2005). However, the literature that examine the indirect effects of such reforms on economic outcomes concentrates on economic growth and human development. Therefore, our paper sheds light on the existences of a particular transmission channel between power sector reform and economic growth. Our paper also adds to the literature by using high tech exports as a proxy for technological change.

Second, by using an Instrumental Variable – Two-Stage Least Squares (IV-2SLS) approach, this article applies a new methodology to study the effects of power sector reforms on technological change, an economic outcome. The number of power sector reforms in neighboring countries has been used by other studies to assess the effects of power sector reforms on transmission and distribution losses. However, to the best of our knowledge, this instrumental variable strategy has not been used to assess the effect of such reforms on economic variables. We build on the related literature to introduce a more robust causal interpretation of the effects of power sector reforms on economic outcomes. Since a large number of studies have used cross-sectional evidence, another contribution of this paper is to use panel data with country and time fixed effects to account for unobserved characteristics that might drive the results.

Third, this article provides new empirical evidence on economic development among Arab League member countries. The region, and more particularly its dynamics in terms of technological development, has been less studied than others. Despite long-lasting conflicts in several areas, many reforms of competition rules, ICT, or energy have been implemented but have been only scarcely discussed in the literature. The

effects of such reforms may pave way to evolutions and technological progress of the region, and therefore deserve greater scrutiny.

The remainder of the article is organized as follows. Section 2 reviews the literature. Section 3 describes the data. Section 4 details the empirical strategy and section 5 discusses the results. Finally, section 6 concludes.

2 Literature Review

The literature that assesses the impact of power sector reforms on technological change is rather scarce. Some articles investigate the impact of such reforms on direct outcomes, such as power generation, electricity consumption and transmission and distribution loss, while some others concentrate on the impact of these reforms on broader economic or development indicators, often using a more literary approach. As discussed in Jamasb et al. (2005), a large share of the literature on power sector reforms lacks appropriate identification strategy. To the best of our knowledge, our paper is the first, within this literature, to assess the impact of power sector reforms on technological change in a consistent way.

The results of the literature on power sector reforms are often contradictory. Nagayama (2009) finds a positive effect of power sector reforms on electricity prices using a panel with fixed effects and an IV approach. Using data from a household survey in Japan, Shin and Managi (2017) find however that such reforms have a positive impact on consumers' satisfaction, as they allow them a wider choice of energy providers.

Parker and Kirkpatrick (2002) aim to identify the effects of power reform in developing countries. The authors test whether privatizations lead to higher operating efficiency and capacity utilization, to higher residential prices and to lower industrial prices. Competition, it is hypothesized, should lead to larger capacity, higher output and greater labor productivity, as well as to higher residential and lower industrial prices. The existence of an independent regulator is expected to improve productive efficiency and to lead to higher residential prices. Privatizations with supportive (independent) regulatory framework should lead to higher output and capacity.

Zhang et al. (2005) reject the hypothesis that privatizations *per se* lead to higher operating efficiency in terms of labor productivity. However, capacity utilization does improve under privatization, independently from competition and regulation. Their results also suggest that privatizations will lead to increased capacity and consequently higher output, provided that there is a supportive regulatory regime in place. With respect to the effect on prices, the estimated coefficients are not significant for privatization, and there is only partial support for the hypothesis that competition will lower

industrial prices.

Many articles have focused on the African continent, where energetic needs are more binding. From a literary perspective, Turkson and Wohlgemuth (2001) provides an overview of power sector reforms lessons in this continend and discuss the numerous chalenges. Also from a literary approach, Karekezi and Kimani (2002) assess the challenges and prospects of power sector reforms in southern and eastern Africa and find a positive effect on power generation, local participation in the power sector and electrification of the poor, but also poor performance at the transmission and distribution end. The authors also discuss some perspectives for these reforms to have a more positive impact on the poor. In a broader set of developing countries, Gratwick and Eberhard (2008) revue the practices and issues concerning the implementation of power sector reforms and the institutional arrangements linked with the appearence of hybrid market structures.

Wamukonya (2003) finds, in a literary analysis, that power sector reforms have not be able to reach the goals that were set before their introduction and that profound changes are required for them to be helpfull in meeting sustainable development goals. An explanation for this result is provided in Nepal and Jamasb (2012) as the authors discuss the importance of institutions and the synchronization with reforms in different sectors for them to be effective. Several papers, however, have investigated the association between energy consumption and GDP growth in country-case empirical studies. Kebede et al. (2010) empirically find a positive association in Sub-Saharan Africa, Mozumder and Marathe (2007) finds the same result in Bangladesh using cointegration and vector error correction model, Ghosh (2002) also obtains this results in India using a Granger causality approach while Baranzini et al. (2013) perform this analysis in the case of Switzerland. At the same time, Nagayama (2010) provides some evidence indicating that power sector reforms have a positive effect on power generation and a negative effect on transmission and distribution losses: this result is confirmed in Urpelainen et al. (2018) as the authors obtain a similar result using an Instrumental variable approach in a panel dataset of 184 countries. These papers together suggest therefore that such reforms might have a positive impact on growth, as indicated by the findings of Cheng et al. (2013) for the Chinese economy.

Zhang et al. (2008) find that, while privatization and regulation do not necessarily lead to tangible gains, despite some interactions, increase in competition allows to obtain better performances within the power generation sector. This result suggests that aggregate indicators for power sector reforms might not result entirely appropriate as they would not allow to discriminate among the types of reforms.

The literature on power sector reforms in Arab countries and the MENA region

also frequently lacks, with notable exceptions, appropriate identification strategies. Dyllick-Brenzinger and Finger (2013) analyze the power sector reforms in five large, oil- and gas-exporting member countries of the Arab League since the 1990s, while Griffiths (2017) provides a similar assessment on energy policy in the broader MENA region. Contrary to the findings of the literature on other regions, Ozturk and Acaravci (2011) finds mixed evidence of a causal link between energy consumption and GDP in the MENA region: while this relation can be established using an ARDL bound testing approach in Egypt, Israel, Oman and Saudi Arabia, it is not significant in Iran, Morocco and Syria. For Jordan however, Istaiteyeh and Ismail (2018) finds that the GDP per capita Granger causes per capita electricity consumption.

Belaïd and Zrelli (2019) test the existence of a causal relation between GDP and energy consumption in 9 southern and northern Mediterranean countries, by also taking into account the CO_2 emission, while Boukhelkhal and Bengana (2018) perform a relatively similar exercise for North African countries. Their results provide mixed evidence with respect to the existence of such a causal relation.

In this context, our paper adds to the literature on power sector reforms by asking a novel research question that would allow to assess the effectiveness of one transmission channel of such reforms on economic growth, through technological change. Other contributions to this literature consists in the adoption of a robust identification strategy and a cross-country approach for a region that has not yet received much attention in the literature.

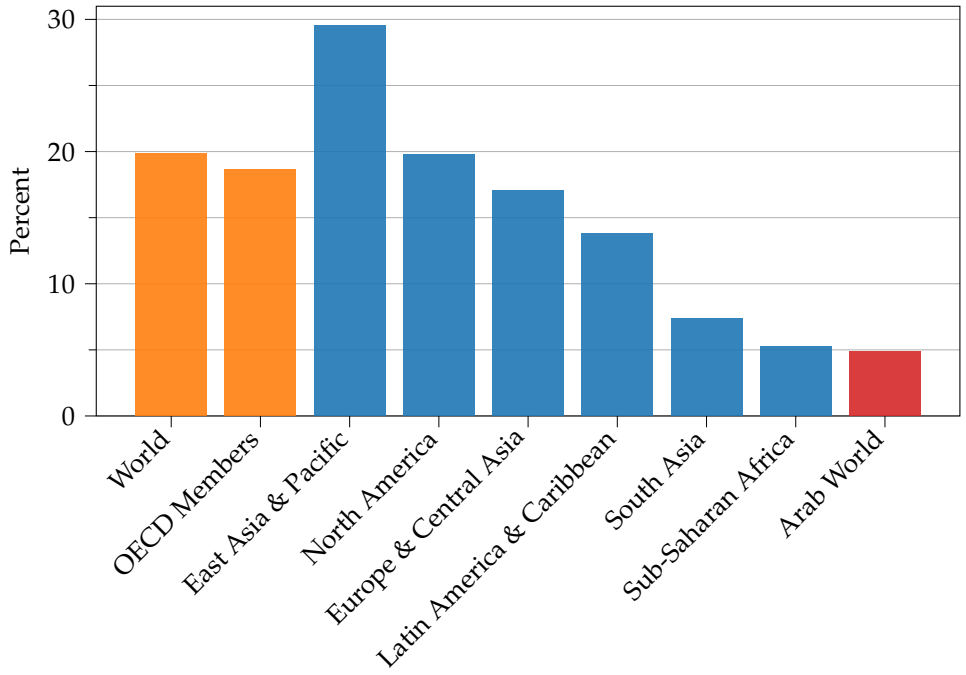
3 Data

The main dependent variable is high-tech exports of 18 Arab countries. We use two versions of high-tech exports. The first version is high-tech exports expressed as a percentage of manufacture exports, and this variable is taken from the World Development Indicators (WDI). The second version is the share of high-tech exports in GDP, computed as the value of high-tech exports divided by the GDP, in current USD. Both variables are also taken from the WDI. According to the World Bank definition, high-tech exports are products with a high intensity in Research and Development (R&D), such as the aerospatial sector, computers, pharmaceuticals, scientific instruments, and electrical machinery. We use this variable as a proxy for technological adoption in Arab League member countries.

The increasing share of technologically intensive products in global trade has shed light on the fact that technology and technological capabilities as a major factor for competitiveness and growth. Notably, emerging countries are progressively becom-

ing the exporters of the products that are technologically more intensive. For a long time, developing economies have exported low and medium-tech products. Hence, the increase in high-tech exports reflects technological upgrading and adopting in the production function of firms. We can consider the exprots of high-tech products as a measure of technological adoption and upgrading since the alternative was producing low medium-tech products. Increasing the technological intensity of exports requires to invest more in high-tech and medium-tech R&D activities and overcome the technological barriers: if firms want to compete in foreign markets with hightech products, they should have at least upgraded their technology, or adopted new ones.

Figure 1 – High-Tech Exports (2012 - 2018), by Region



Source: World Development Indicators dataset, elaborated by the authors. The graph shows the average share of High-Tech exports in total manufacture exports between 2012 and 2018. Geographic zones correspond to the World Bank definition.

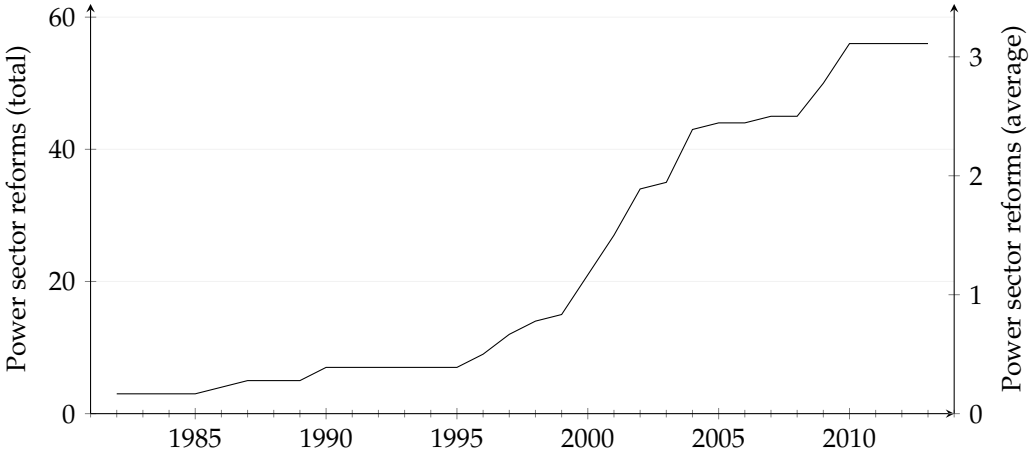
Technologicallly intensive products are the science-based products that require high-skill labour to apply the most sophisticated new technologies expeditiously. These products also require sophisticated instruments and techniques in order to be adopted. We can consider that high-tech exports are an indication of having adopted high-tech intermediary goods and employed highly skilled workers, developing therefore more sophisticated production processes. However, high-tech exports in one country may come from merely assembling imported parts with some local physical or technological

inputs, while in other countries, the same export may involve substantial use of local physical and technological inputs and a more complex production process. Moreover, the ability to produce technologically intensive products is incurred by R&D and innovation, two imprescindible tools to achieve technological upgrading.

A technologically intensive export structure requires technological upgrading. As technological capabilities make the production process more efficient, it thereby reduces the vulnerability of countries to market fluctuations. Thus, countries having a higher degree of technological intensity in their trade with a large proportion of high-tech goods, especially in their exports structure, have significantly improved their importance in the world exports and experience gained in their trade share. Moreover, a technologically intensive export structure contributes more to the long-run growth as compared to that of a low-technological one (Rodrik, 2016, among others). This is because technological-intensive products tend to be highly income elastic, create new demands, substitute older products, and tend to grow faster in trade.

Figure 1 shows the average share of high-tech exports in total manufacture exports between 2012 and 2018 by region, according to the World Bank classification. While this share reaches 29.5% in East Asia & Pacific, one of the fastest-growing regions with several countries that have adopted and export-led growth model, high-tech exports only represent 4.9% of total manufacture exports in the Arab World, the lowest ratio in the world.

Figure 2 – Power Sector Reforms in Arab League member countries



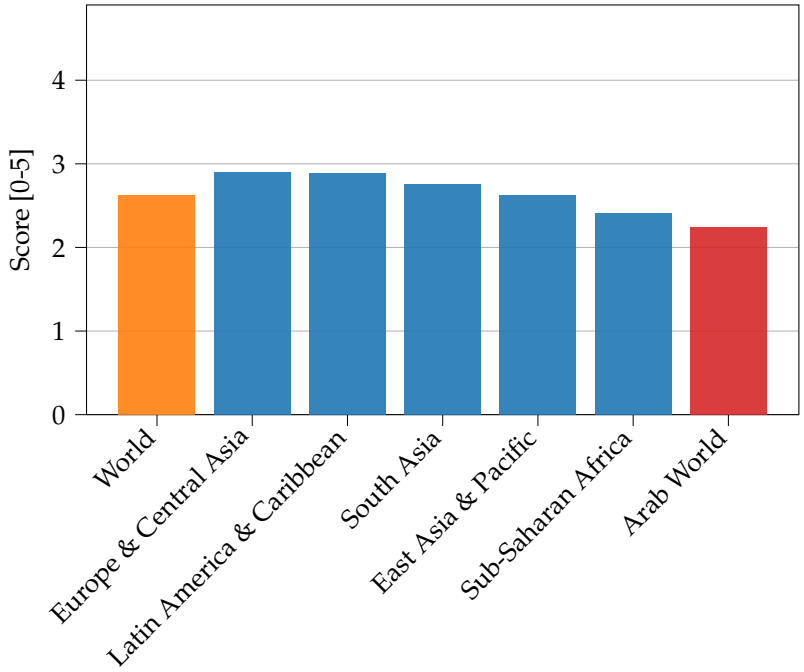
Source: Urpelainen and Yang (2019), elaborated by the authors. Because of missing data, the sample does not include Comoros, Mauritania, West Bank and Gaza and Somalia.

The main explanatory variable is an indicator for hybrid power sector reforms, built by Urpelainen and Yang (2019). The indicator takes values from zero to five. It consists

in five reforms: the number of corporatization, liberalization, regulatory, unbundling, and independent power generation reforms. Urpelainen and Yang (2019) depend on the data constructed by Erdogdu (2011). For each type of reform, he addresses the first instance of reform. Urpelainen and Yang (2019) use these data and sum it up to construct an overall measure of reforms. Figure 2 presents the data for Arab League member states and evidences the high number of reforms that were implemented in the region starting in the second half of the 1990s: from a total of 7 reforms in 1995 in the region, this number has increased to 56 in 2013.

However, as shown in Figure 3, the Arab World lags behind the other regions and also ranks last in the world for this indicator in the most recent period available (2000-2013). The resulting sub-optimal energy provision to industrial firms might prevent them from adopting the more efficient production processes that are required to produce high-tech goods and gain global market shares in high value-added sectors.

Figure 3 – Power Sector Reforms (2000 - 2013), by Region



Source: Urpelainen and Yang (2019), elaborated by the authors. The graph shows the average score for power sector reforms between 2000 and 2013. Geographic zones correspond to the World Bank definition. A majorty of high-income countries are not included in the database.

We use additional control variables since they might be associated with both power sector reform and high-tech exports. We obtain data on gross capital formation from the WDI dataset, expressed as a share of GDP. Gross fixed capital formation (formerly

gross domestic fixed investment) includes land improvements, plant, machinery, and equipment purchases, and the construction of roads, railways, and commercial and industrial buildings. Moreover, we control for land area per inhabitant, constructed from the WDI. Land area is a country's total area, excluding inland water bodies and exclusive economic zones. It is measured in square kilometers.

We obtain data on gross tertiary school enrollment, expressed in percentage, from the WDI dataset. Gross enrollment ratio is the ratio of total enrollment. Tertiary education, whether or not to an advanced research qualification, normally requires, as a minimum condition of admission, the successful completion of education at the secondary level.

We obtain data on imports of goods and services as a share of GDP from the WDI dataset. Imports of goods and services represent the value of all goods and other market services received from the rest of the world. They include the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction, financial, information, business, personal, and government services.

Data on the Polity IV dataset is retrieved from the Center for Systematic Peace. This dataset covers all major, independent states in the global system over the period 1800-2017. Data ranges from -10 to 10. It is used as a measure for democracy.

The data for real GDP and R&D expenditure as a share of GDP are also retrieved from the WDI dataset. It includes expenditures of Business enterprises, Government, Higher education and Private non-profit. R&D covers basic research, applied research, and experimental development.

We use data on ICT imports from the WDI. Information and communication technology goods imports include computers and peripheral equipment, communication equipment, consumer electronic equipment, electronic components, and other information and technology goods. Data on FDI inflow are obtained in constant USD, also from the WDI dataset. It includes the sum of equity capital, reinvestment of earnings, and other capital. It is defined as ownership of 10 percent or more of the ordinary shares of voting.

We obtain a series of variables from the Heritage Index of Economic Freedom dataset. More democratic countries are expected to adopt a more freemarket economy, opening the market to more competition and liberalization, compared to more autocratic and centralized countries. The number of power sector reforms should be expected to be associated with more economic freedom. The effect of economic freedom can be expected in high-tech exports since financial, trade, and monetary freedom are expected to be beneficial for domestic firms. For example, trade freedom enables firms to import

high-quality intermediate input which might improve the performance of such firms in the foreign market. Also, producing high-tech products might need advanced intermediate inputs which are obtained from abroad. Financial freedom can easily provide firms with access to finance and high-quality financial services, which might improve their performance to buy more machines and advanced input, and therefore achieve technological upgrading. Moreover, greater business freedom might improve the performance of firms in the foreign marketsince it can reduce the cost burdens on firms and provide opportunities to small firms to enter the market and increase competition. Controlling for the variables of economic freedom is important since the variables of economic freedom might drive the results.

The government expenditure indicator is negatively related to the share of government expenditures in the GDP. It includes consumption and transfers, the net acquisition of nonfinancial assets, while tax burden represents the fiscal freedom and includes direct and direct taxes imposed by government as a share of GDP. The rule of law indicator measures to what extent agents have confidence in rules of society, and the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence. The business freedom indicator measures to what extent the regulatory and infrastructure environments constrain the efficient operation of businesses, and trade freedom measures to what extent the tariff and nontariff barriers affect imports and exports of goods and services. The financial freedom and government integrity index is also obtained from the Heritage Index of Economic Freedom dataset. The index score depends on government regulation of financial services, the degree of state intervention in banks, government influence on the allocation of credit, the extent of financial and capital market development, and openness to foreign competition. Financial freedom is an indicator of banking efficiency, government control and interference in the financial sector.

The monetary freedom index measures the price stability, and the investment freedom index measures regulatory constraints on investment. Points are deducted from the ideal score of 100 for each of the restrictions to investment freedom. The few governments that impose so many restrictions that they amount to more than 100 points in deductions have their scores set at zero. The government effectiveness indicator measures the quality of public services, civil service and independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. Finally, we also include data on overall score of economic freedom from the Heritage Index of Economic Freedom dataset.

Our instrumental variable is the sum the hybrid power sector reforms of neighboring countries, that we construct based on data by Urpelainen and Yang (2019). We

consider all countries whose borders are connected by land or by about 500 miles of water or less. To construct this indicator, we use data from two sources[2]. To account for average of hybrid power sector reforms of neighbors, we sum hybrid power sector reforms and divide it on the number of neighboring countries.

4 Empirical Methodology

4.1 OLS Approach

The goal of our empirical analysis is to investigate the impact of hybrid power sector reforms on technological adoption among Arab League members. To investigate this effect, we use the number of individual reforms constructed by Urpelainen and Yang (2019) and assess whether these reforms result in an increase in high-tech exports, which we consider a proxy of technological adoption.

The data cover the period spanning from 1982 to 2013 and include 18 Arab League member countries. The analysis uses a long time period in order to cover the majority of hybrid power sector reforms adopted in the region (Urpelainen and Yang, 2019). To test the effect of these reforms on technological adoption in the Arab countries, we estimate the baseline equations (1) using an OLS procedure:

$$Exp_{i,t} = \alpha_0 + \alpha_1 Reform_{i,t-3} + \beta_1 \mathbf{X'}_{i,t} + \gamma_i + \varphi_t + \varepsilon_{i,t} \tag{1}$$

where t denotes the year and i the country. The main dependent variable is high-tech exports ($Exp_{i,t}$), which represents an proxy for technology adoption. The main independent variables, $Reform_{i,t-3}$, is a discrete variable indicating the number of hybrid power sector reforms, lagged by three years, which takes values from zero to five. It indicates five reforms: the number of corporatization, liberalization, regulatory, unbundling, and independent power generation reforms. Our coefficient of interest, α_1, corresponds to the estimated relationship between power sector reforms adoption High-Technology Exports.

The vector $\mathbf{X'}_{i,t}$ denotes a set of country-level covariates which may confound the effect of power sector reforms, such as institutional variables. Equation (1) includes also country fixed effects (γ_i) which control for unobserved country characteristics that are constant over time. Using country fixed effect allows to confirm that unobservable time-invariant country-specific factors do not drive the effect of power sector reforms on our dependent variable. In addition, using time fixed effects (φ_t) controls for unobserved factors which affect all countries at the same time, such as global demand

[2] http://ports.com/ and https://geology.com/

shocks. The random error term is denoted by $\varepsilon_{i,t}$.

4.2 Instrumental Variable Approach

Several difficulties arise when analyzing the effects of hybrid power sector reforms on technology adoption. First, the high likelihood of reverse causality leads to biased OLS estimates: if reforms are expected to affect high-tech exports performance, their adoption might also be explained by these exports performance. For example, an already burgeoning high-tech exporting sector might lead to reforms adoption or conversely, a stagnation of this sector might lead to delays in reforms adoption (Mrad, 2017). Second, other country characteristics might be associated with both hybrid power sector reforms and high-tech exports, and these factors might confound the effects of the former on the latter. Institutional quality, for example, is likely to be positively correlated with power sector reforms and also affect the export performances. Moreover, only countries with high-performing electric power industries — due to broader good governance and policy, for example — might take up reforms in the first place. Hence, OLS estimations estimates must be interpreted with caution and no causal inference can be drawn.

To overcome these pitfalls, we first take the three years lag value of power sector reforms, which excludes the issue of reverse causality. This also allows to take into account the time that is necessary for any structural reform to affect incentives, behaviours and hence economic outcomes: several years are likely to be needed for a power sector reform to improving companies' ability to adopt new technology through improved power generation and distribution. However, endogeneity concerns due to omitted variable bias remain. Therefore, we adopt and instrumental variable approach and use the sum of power sector reforms in neighbouring countries as an instrumental variable for power sector reforms in country i. Equation (2), which corresponds to the second stage, and equation (3), which corresponds to the first stage, are estimated using a Two-Stage Least Squares (2SLS) procedure:

$$Exp_{i,t} = \alpha_0 + \alpha_1 \widehat{Reform}_{i,t-3} + \beta_1 \mathbf{X}'_{i,t} + \gamma_i + \varphi_t + \varepsilon_{i,t} \tag{2}$$

$$Reform_{i,t-3} = \lambda_0 + \lambda_1 Neighbour's\ Reform_{i,t-3} + \mu_{i,t} \tag{3}$$

For the neighboring countries power sector reforms to be a valid instrument, this variable must be relevant and must meet the exclusion restriction criteria. Foster et al. (2017) argue that geographic region is a strong effective factor of power reform diffusion across countries, more than other country characteristics, such as income group

or the size of the power system, as reforms adoption in one country can lead to mimicking behaviours and increased competition from its neighbours. Furthermore, the theory of regulatory competition shows that there is positive relationship between the implementation of regulatory reform and reform activities in the neighbouring countries in the region: given competition for investment between neighbouring countries, the neighbours adopt similar institutional regulations and reforms to compete and attract more investments (Gilardi et al., 2006).

The non-violation of exclusion restriction is respected if the instrumental variable only affects the dependent variable through the explanatory variable, excluding therefore any unobserved channel. This is the case when refering to power sector reforms. First, neighbouring countries power sector reforms have no direct effects on international trade between the Arab countries because of the lack of commercial integration and interconnection within the MENA region. Overall, the Arab League members remain scarcely regionally integrated in terms of trade and investment flows. The main barriers to growth in trade and investment are weak implementation and enforcement of regional trade agreements, wars, sanctions and political barriers in the region, weak institutions, the lack of infrastructure and the prominent role of state-owned enterprises. There is, however, no indication of more rapid regional integration over time, suggesting that recent trade agreements among Arab countries have not stimulated regional trade to a greater extent than external trade, and non-tariff barriers continue to impede regional integration (Saidi and Prasad, 2018). Other barriers hindering the trade integrations between Arab region countries include differences in national economic systems, the similarity of production and trade structures, the overprotection and heavy reliance on trade taxes, the low quality and thus low competitiveness of commodities compared to imported products from other regions of the world and the lack of market information and adequate infrastructure. Meanwhile, the institutional factors include the high sensitivity of trade to political relationships between Arab countries, the lack of commitment to the regional agreements, the absence of adequate trade financing schemes at the regional level, and the bureaucracy and complications of trade-related procedures, among others (Abu Hatab, 2015).

Because interconnections between Arab countries' electric power grid are limited, one country's reforms have no direct effect on the electricity generation and transmission in other countries, except through the adoption of power sector reforms themselves in these countries. Technical performance improvements are limited to the national electricity generation, transmission, and distribution systems, influenced by the rule changes. The notable advantage of this instrument is that it uses small geographic reference areas for predicting the regional diffusion of reforms (Urpelainen and Yang,

2019).

Intra-regional FDI inflows mainly originate from Gulf Cooperation Council (GCC) economies, and intra-regional FDI excluding outflows from GCC remain relatively low, despite the existence of a variety of preferential and regional trade agreements as well as bilateral investment treaties. For example, intra-regional FDI between MENA countries only accounted for 6% of total FDI flows to the region in 2012 despite the existence of the Agadir Agreement between Egypt, Jordan, Morocco and Tunisia (OECD, 2014). Intra-regional investment flows remain below potential, especially amongst regional trading partners. Therefore, inter regional investment among Arab region countries is not a potential channel which violates exclusion restriction. Political barriers within the region, weak institutions and the lack of infrastructure discourage most potential inter-regional investment. FDI are not a potential threat to the exclusion restriction because most of FDI flows are from developed to developing countries. Moreover, as it is relatively scarce, regional trade is not a threat either. Current investments are only oriented towards sectors such as the real estate sector, the coal, oil and gas sector and the chemicals sector, not towards the high-tech or ICT sectors. For example, real estate sector accounted for 32.4% of FDI, while the coal, oil and gas sector accounted for 30% and the chemicals sector accounted for 9.6% in 2014. To guarantee that the effect of power sector reforms on high-tech exports is not confounded by any other factors and to rule out alternative potential threats, we control for several variables in our regression. Moreover, we want to ensure that any possible direct spillovers are considered.

Nevertheless, power sector reforms in one country could directly affect the high-tech exports of neighbouring countries, as better power sector performances could allow this country to increase its market shares in other regions at the expense of its neighbours' exporting sectors. This direct relationship is limited by the relatively low level of high-tech exports of Arab League members, and the bias it could introduce in our regressions would be a downward bias, increasing therefore the confidence in a positive relationship between power sector reforms and high-tech exports.

5 Results

OLS estimates of equation (1) are reported in Table 1 with the inclusion of different covariates. All models include country and year fixed effects. The only difference between models is the choice of control variables and whether standard errors are clustered. OLS estimates indicate that the number of power sector reforms predicts high-tech exports only when standard errors are not clustered at the country level. In the first column, we control for gross capital formation (in % of GDP), land area in square

km per inhabitant, gross tertiary school enrollment (in percentage), real GDP (in log), and the Polity-IV index. These covariates are included to rule out any confounders which may drive the results. The estimated coefficient for hybrid power sector reform, α_1, is positive and statistically significant at the 5% confidence level. Specifically, a one unit increase in hybrid power sector reform is associated with an increase in high-tech exports share of manufactore exports of 0.43 percentage points.

Table 1 – Baseline results: OLS estimates

	High-Tech Exports (% of manufacture exports)			
	(1)	(2)	(3)	(4)
Power Sector Reform$_{t-3}$	0.430**	0.430	0.295*	0.295
	(0.198)	(0.265)	(0.169)	(0.248)
Capital Formation	-0.070*	-0.070	-0.094***	-0.094
	(0.039)	(0.076)	(0.035)	(0.062)
Land per inhab.	74.89***	74.89**	58.14***	58.14**
	(19.07)	(25.05)	(17.77)	(22.39)
ln(Real GDP)	2.636	2.636	1.691	1.691
	(1.718)	(2.075)	(1.398)	(1.702)
Polity IV	0.097	0.097	0.057	0.057
	(0.095)	(0.101)	(0.084)	(0.087)
School Enrollment	0.029	0.029		
	(0.035)	(0.078)		
Openness			0.071***	0.071*
			(0.022)	(0.039)
Constant	-67.27	-67.27	-43.64	-43.64
	(44.40)	(53.74)	(35.68)	(44.85)
Observations	196	196	255	255
Country FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Clustered SE	No	Yes	No	Yes
R^2	0.28	0.28	0.22	0.22

P-value in parenthesis. * Significant at the 10 percent level, ** Significant at the 5 percent level, *** Significant at the 1 percent level.

The regression includes year and country fixed effect without adding any clustering by country. Regarding the controls, the coefficients of the baseline regression have the expected signs. For example, gross capital formation (formerly gross domestic investment) consists in outlays on additions to the fixed assets of the economy. It should increase productive capacity and increase potential output, thus stimulating future economic growth, employment creation and a rise in living standards. However, the sign is negative and significant at the 10% level in the regression.

In column 2 of table 1, we run the same regression as previously except for the

fact that we include clustered standard error at the country level. Results show that there is no significant effect of hybrid power sector reform on high-tech exports in this case. Columns 3 and 4 of Table 1 present estimates once we control for trade openness, measures by imports of goods and services as a share of GDP, instead of tertiary school enrollment. In column 3, OLS results show a positive and statistically significant effect of hybrid power sector reform on high-tech exports. A 1 unit increase in hybrid power sector reform leads to an increase in high-tech exports by 0.30 percent points in terms of percentage of manufacture exports. The regression includes year and country fixed effect without clustering the standard error at country level. In column 4, OLS results evidence that the statistical significance of this result disappears when standard errors are clustered at the country level.

Due to the likely presence of endogeneity arising from reverse causality and the presence of further country characteristics associated with both hybrid power sector reforms and technological outcomes, OLS results are biased and impede a causal interpretation of the relationship. Hence, we follow the instrumental variable approach to address the concern of endogeneity problem. We use the sum of hybrid power sector reform of neighbors as an instrumental variable.

Table 2 presents the 2SLS estimates of equations (2) and (3), using the same specifications as those presented in Table 1 and including first and second stage diagnostic tests. Column 1 of Table 2 presents the 2SLS estimates without clustering the standard error at the country level. We still find positive and significant results at the 5% confidence level. However, the Durbin-Wu-Hausman test indicates a statistically significant difference between the OLS and the IV estimator. Polity IV is not a statistically significant coefficient for high-tech exports. Unsurprisingly, a higher real GDP tends to be associated with a higher share of high-tech exports in manufacture exports. On the other hand, the coefficient for tertiary school enrollment is negative but not statistically significant.

In column 2 of Table 2, the estimated coefficient for hybrid power sector reform, α_1, is now still positive and statistically significant at the 5% confidence level. Specifically, a 1 unit increase in hybrid power sector reform leads to a 2.98 percentage points increase in the share of high-tech exports in total manufacture exports. The regression includes year and country fixed effects, as well as clustered standard errors at the country level. We control for the same covariates as in the OLS regressions presented in table 1 to rule out any potential threats of confounders, as not controlling for these covariates might lead to falsely attributing their effects to hybrid power sector reform. The coefficients of the IV regression have the expected signs except for tertiary school enrollment, which is insignificant. The magnitude of the coefficient increased from 0.43

to 2.98 percentage points. Such increase indicates that the IV regressions capture more effects compared to the OLS regressions. Capital fixed formation and Polity IV have no statistically significant coefficients, while a higher real GDP tends to be associated with a higher share of high-tech exports. Results show that a large size of land is a good predictor for high-tech exports. The Kleibergen-Paap F statistics, which is used when standard errors are not assumed to be i.i.d., is greater than 10 when standard errors are clustered: this implies that we can reject the possibility of weak instruments. For all second stage regressions, the Durbin-Wu-Hausman tests indicate that we cannot rule out the possibility that the OLS estimator is exogenous.

Table 2 – Baseline results: IV estimates with additional controls

	High-Tech Exports (% of manufacture exports)			
	(1)	(2)	(3)	(4)
Second stage: Dependent variable is High-Tech Exports				
Power Sector Reform$_{t-3}$	2.986**	2.986**	2.377**	2.377**
	(1.495)	(1.422)	(1.156)	(1.070)
Capital Formation	-0.089*	-0.089	-0.135***	-0.135*
	(0.052)	(0.073)	(0.049)	(0.081)
Land per inhab.	126.8***	126.8***	100.4***	100.4***
	(38.95)	(33.66)	(31.67)	(30.61)
ln(Real GDP)	6.716**	6.716**	5.716**	5.716*
	(3.252)	(3.204)	(2.782)	(3.180)
Polity IV	0.007	0.007	-0.048	-0.048
	(0.135)	(0.302)	(0.117)	(0.254)
School Enrollment	-0.028	-0.028		
	(0.056)	(0.101)		
Openness			0.095***	0.095*
			(0.030)	(0.051)
First stage: Dependent variable is Power Sector Reform$_{t-3}$				
PSR in neighbouring countries$_{t-3}$	0.054**	0.054***	0.063**	0.063***
	(0.025)	(0.016)	(0.024)	(0.020)
Observations	196	196	254	254
Number of Countries	10	10	12	12
Country FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Clustered SE	No	Yes	No	Yes
DW Hausman Test	0.012	0.261	0.016	0.278
Kleibergen-Paap F-Stat	-	11.02	-	10.27

P-value in parenthesis. * Significant at the 10 percent level, ** Significant at the 5 percent level, *** Significant at the 1 percent level.

In column 3 of Table 2, the estimated coefficient for hybrid power sector reform, α_1, is positive and statistically significant at the 5% level of confidence. More specifi-

cally, a 1 unit increase in hybrid power sector reform leads to a 2.38 percentage point increase in the share of high-tech exports in total manufacture exports. The IV approach improves the results compared to the OLS estimates. The regression includes year and country fixed effect without clustering the standard error at the country level. In column 4 of Table 2, while when we cluster the standard error at the country level, we obtain positive and statistically significant results, at the 5% level of confidence. Moreover, the Kleibergen-Paap F statistics indicates that weak instrumentation can be rejected. As previously, the Durbin-Wu-Hausman test indicate that we cannot rule out the possibility that the OLS estimator is exogenous

Table 3 presents results from 2SLS estimations of equations (2) and (3) when additional or alternative covariates are inluded in order to test the robustness of the results of the baseline specification. In column 1 of Table 3, we control for rule of law index (retrieved from the Worldwide Governance Indicators). Rule of law captures confidence in the judicial system, contract enforcement, property rights, law enforcement against violent and organized crime, and judicial independence. It is a proxy for the overall quality of the legal system. An efficient rule of law can facilitate trade. North (1986, 1993) argues that high-quality institutions are crucial for economic growth to facilitate efficient transactions between individuals and firms. Countries experiencing unstable institutions will hamper growth, innovation and exports. Neglecting such control might lead to falsely attributing its effect to hybrid power sector reforms. Furthermore, we control for capital fixed formation as indicator for domestic investment. Its coefficient is positive but insignificant. Moreover, we control for tax burdens as a measure of fiscal freedom, government spending, and research and development expenditure as a share of GDP. None of these control variables are significant. After controlling for rule of law and other different covariates, results show that coefficient of hybrid power sector reform is still positive and significant. The Kleibergen-Paap F statistics is greater than 10, which implies that we can reject the possibility of weak instruments. Durbin-Wu-Hausman tests indicate no statistically significant difference between the OLS fixed effects and the IV estimators.

In column 2 of Table 3, we control for two new covariates, FDI inflows and business freedom. Controlling for FDI ensures that the power sector reforms of neighbours can only affect high-tech exports of a country through the power sector reforms of that country. The coefficient of hybrid power sector reform is still positive and statistically significant. Hence, we can argue that FDI is not a potential channel that could violate the exclusion restriction.

Table 3 – IV estimates: further robustness checks

	High-Tech Exports (% of manufacture exports)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Second stage: Dependent variable is High-Tech Exports								
Power Sector Reform$_{t-3}$	1.138*	1.665*	0.957***	0.964***	1.076***	0.725**	1.386***	2.059***
	(0.619)	(0.970)	(0.369)	(0.323)	(0.194)	(0.305)	(0.306)	(0.547)
R&D	-0.817	-1.497**	-0.423	-0.385	-0.257	-0.668	-0.418	-1.206
	(0.519)	(0.670)	(0.801)	(0.835)	(0.420)	(0.768)	(0.435)	(0.733)
Fixed Cap. Formation	0.046	0.011			-0.099		-0.233***	-0.351***
	(0.121)	(0.073)			(0.105)		(0.084)	(0.054)
Gov. Spending (EF)	0.032		0.021	0.022	0.021	0.008	-0.045***	-0.041***
	(0.033)		(0.021)	(0.020)	(0.027)	(0.014)	(0.017)	(0.015)
Rule of Law (WGI)	1.826	1.917						
	(1.250)	(1.788)						
Tax Burden (EF)	0.035	0.002						
	(0.028)	(0.013)						
Openness			0.034	0.032	0.025			
			(0.033)	(0.043)	(0.045)			
School Enrollment			0.003	0.004	0.040	0.023	0.006	0.017
			(0.010)	(0.018)	(0.060)	(0.014)	(0.027)	(0.043)
FDI inflows		-0.00						
		(0.00)						
ICT goods imports						-12.52	77.21*	60.16
						(33.30)	(39.97)	(49.75)
Business Freedom		0.007						
		(0.031)						
Polity IV				0.007	0.031	0.062*		
				(0.054)	(0.055)	(0.034)		
Trade Freedom (EF)			-0.006	-0.006	-0.014	-0.002		
			(0.019)	(0.018)	(0.013)	(0.015)		
Economic Freedom							0.108	0.109
							(0.091)	(0.094)
Oil Rents								-0.130***
								(0.033)
First stage: Dependent variable is Power Sector Reform$_{t-3}$								
PSR in neighbouring countries$_{t-3}$	0.073***	0.045***	0.070***	0.076***	0.117***	0.086***	0.097***	0.081***
	(0.023)	(0.013)	(0.022)	(0.023)	(0.026)	(0.013)	(0.022)	(0.024)
Observations	71	71	68	68	65	59	56	56
Number of Countries	9	9	8	8	8	7	7	7
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered SE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
DW Hausman Test	0.156	0.117	0.132	0.107	0.041	0.201	0.120	
Kleibergen-Paap F-Stat	10.19	12.38	10.28	11.05	20.70	44.48	19.10	11.44

P-value in parenthesis. * Significant at the 10 percent level, ** Significant at the 5 percent level, *** Significant at the 1 percent level.

In column 3 of Table 3, we further check the robustness of our results by control-

ling for a new covariate which is trade freedom. It measure the extent to which tariff and non-tariff barriers affect imports and exports of goods and services. Trade limitations also put advanced-technology products and services beyond the reach of local entrepreneurs, limiting their own productive development (Miller et al., 2019). Hence, trade freedom may confound the previous results. However, when including this variable, we obtain positive and statistically significant results at the 1% level of confidence. Therefore, controlling for such variable improves the robustness of our baseline results. A 1 unit increase in hybrid power sector reforms leads to a 0.96 percentage points increase in the share of high-tech exports in total manufacture exports. The Kleibergen-Paap F statistics is still greater than 10 and the Durbin-Wu-Hausman test indicates no statistically significant difference between the OLS fixed effects and the IV estimators.

In column 4 of Table 3, we use the same previous specification except for an additional control covariate (the Polity IV index). It is argued that democracy leads to open trade relations and higher trade levels, faster agreements on lower trade barriers during a negotiation, and a higher cost of trade wars (Morrow et al., 1998; Mansfield et al., 2000). Polachek (1997) states that democratic trading partners are less likely to be involved in combat, as they both try to protect the wealth gained through mutual trade. After controlling for the Polity IV index, our results are still positive and significant at 1% level of confidence. A 1 unit increase in hybrid power sector reform leads to a 0.96 percentage points increase in the share of high-tech exports in manufacture exports. The magnitude of the coefficient of hybrid power sector reform almost does not change compared to the previous regression. The Kleibergen-Paap F statistics is also greater than 10 and the Durbin-Wu-Hausman test indicates no statistically significant difference between the OLS fixed effects and the IV estimators.

In column 5 of Table 3, we complement the previous regression by also controlling for capital fixed formation. The coefficient of hybrid power sector reform is positive and significant at the 1% level. The Kleibergen-Paap F statistics is greater than 10 and the Durbin-Wu-Hausman tests indicates no statistically significant difference between the OLS fixed effects and the IV estimators.

In column 6 of Table 3, we control for a a new covariate, ICT imports expressed as a share of GDP. ICT imports can be a strong determinant of high-tech exports as they can be a strong pathway for foreign knowledge spillovers. ICT imports can stimulate domestic firms to upgrade technology and be competitive in foreign markets. The coefficient of hybrid power sector reform is still robust, positive and significant at the 5% level, although the magnitude has slightly decreased to 0.72 percentage points. The Kleibergen-Paap F statistics is still greater than 10, which allows to reject the possibility of weak instrumentation, and the Durbin-Wu-Hausman test higher than 0.05 indicates

no statistically significant difference between the OLS fixed effects and the IV estimators.

In column 7 of Table 3, we control for fixed capital formation and a new covariate which is the overall Economic Freedom index. In this specification, ICT imports become positive and significant at the 10% level of confidence, reflecting the fact that these imports are a potential channel of technology adoption which might support high-tech exports. The coefficient of hybrid power sector reform is still robust, positive and significant at the 1% level of confidence. The magnitude has increased to 1.39 percentage points. The Kleibergen-Paap F statistics is still greater than 10 and the Durbin-Wu-Hausman tests is greater than 0.05, indicating no statistically significant difference between the OLS fixed effects and the IV estimators.

Column 8 of Table 3 presents the results when we additionally control for oil rents, since it might affect high-tech exports.[3] The relationship appears to be negative, consistent with the fact that high rents may reduce incentives to upgrade technology in order to compete in global markets. This additional control variable does not break the relationship between power sector reforms and high-tech exports however, since the estimated coefficient is positive and significant at the 1% level of confidence, with a value closer to our baseline specifications presented in Table 2 columns 2 and 4.

Table 4 presents additional robustness checks by considering alternative measures of the dependent variable and the instrument. In column 1 of Table 4, we now assess the robustness by using the average, and not the sum, of hybrid power sector reforms in neighboring countries as the instrumental variable for hybrid power sector reforms. We sum the values of power sector reforms of neighboring countries and divide them by the number of these countries. With using same previous combination of control variables, the coefficient of hybrid power sector reform is robust, positive and significant at 5%. Using a different version of the instrumental variable reinforces the robustness of our results. Moreover, we control for a new variable which is financial freedom. A high financial freedom supports the firms' ability to be more productive, innovative and to become high-tech goods exporters (Miller et al., 2019). The Kleibergen-Paap F statistics is greater than 10 for this specification, implying that the possibility of weak instruments can be rejected, and the Durbin-Wu-Hausman test higher than 0.05 indicates no statistically significant difference between the OLS fixed effects and the IV estimators.

[3]Oil rent is measured as the difference between the value of crude oil production at world prices and total costs of production (WDI). Taking the share of fuel exports in total manufacture exports leads to the same result.

Table 4 – IV estimates: additional robustness checks for the dependent variable and the instrument

	% of manufacture exports	*(% of GDP)*			*(% of manufacture exports)*					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Second stage: Dependent variable is High-Tech Exports										
Power Sector Reform$_{t-3}$	1.022**	0.001**	0.001**	0.001**	0.970**	0.955**	1.022**	0.994**	0.989**	0.985**
	(0.445)	(0.001)	(0.001)	(0.001)	(0.464)	(0.401)	(0.445)	(0.440)	(0.389)	(0.396)
R&D	-0.428	-0.002*	-0.004***	-0.003**	-0.627	-0.530	-0.428	-0.729	-0.408	-0.395
	(0.975)	(0.001)	(0.001)	(0.001)	(0.849)	(0.810)	(0.975)	(0.720)	(0.926)	(0.919)
Openness	0.029	0.000	0.000	0.000	0.030	0.027	0.029		0.046	0.042
	(0.027)	(0.000)	(0.000)	(0.000)	(0.029)	(0.027)	(0.027)		(0.037)	(0.040)
Openness	0.010	8.06e-05***	9.92e-05***	7.88e-05***	0.008	0.019	0.010	0.020	0.030	0.027
	(0.009)	(0.000)	(0.000)	(0.000)	(0.008)	(0.018)	(0.009)	(0.013)	(0.020)	(0.021)
Capital Formation		-0.000	-0.000	-0.000					-0.062	-0.059
		(0.000)	(0.000)	(0.000)					(0.048)	(0.046)
Land				0.000						-0.001
				(0.000)						(0.001)
Gov. Spending (EF)	0.021	0.000	0.000	0.000	0.021	0.022	0.021	0.018	0.022	0.022
	(0.018)	(0.000)	(0.000)	(0.000)	(0.017)	(0.018)	(0.018)	(0.015)	(0.017)	(0.016)
Financial Freedom	-0.010						-0.010	-0.013		
	(0.018)						(0.018)	(0.018)		
Business Freedom		1.09e-04***	1.14e-04***	1.14e-04***						
		(2.65e-05)	(2.15e-05)	(2.31e-05)						
Gov. Integrity			0.000							
			(0.000)							
Monetary Freedom					-0.012					
					(0.015)					
Invest. Freedom						-0.016			-0.010	-0.010
						(0.023)			(0.021)	(0.022)
First stage: Dependent variable is Power Sector Reform$_{t-3}$										
Power Sector Reform in neighbouring countries$_{t-3}$	-0.598***	-0.607***	-0.554***	-0.619***	-0.554***	-0.572***	-0.598***	-0.601***	-0.576***	-0.578***
	(0.170)	(0.183)	(0.140)	(0.189)	(0.176)	(0.180)	(0.171)	(0.179)	(0.176)	(0.176)
Observations	68	68	68	68	68	68	68	68	68	68
Number of countries	8	8	8	8	8	8	8	8	8	8
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered SE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
DW Hausman Test	0.219	0.153	0.136	0.152	0.241	0.201	0.219	0.222	0.189	0.195
Kleibergen-Paap F-Stat	12.22	11.05	15.60	10.75	9.89	10.06	12.22	11.32	10.71	10.74

P-value in parenthesis. All standard errors are clustered at the country level. * Significant at the 10 percent level, ** Significant at the 5 percent level, *** Significant at the 1 percent level.

In column 2 of Table 4, we conduct an additional robustness check by using the average of hybrid power sector reforms in neighboring countries as the instrumental variable for hybrid power sector reforms and by using another version of the dependent variable, which is the high-tech exports as a share of GDP. The coefficient of hybrid power sector reform is robust, positive and significant at 5%. Using a different version of the instrumental variable and the dependent variable increases the robustness of the results. Unsurprisingly, tertiary school enrollment rate and business freedom tend to be positively associated with high-tech exports. The Kleibergen-Paap F statistics is still greater than 10 and the Durbin-Wu-Hausman tests is also still greater than 0.05.

In column 3 of Table 4, we add the government integrity index as a new control variable to the previous specification. Corrupt practices of government officials, such as bribery, nepotism, cronyism, patronage, embezzlement and graft, can constrain individual's economic freedom and impact the economic system as a whole. Such practices lead to unfair and unequal treatments, which affect negatively the economic and exporting performances of the economy (Miller et al., 2019). Moreover, excessive and redundant government regulations provide opportunities for bribery and graft. In this specification, the coefficient of hybrid power sector reform is still robust, as it is positive and significant at the 5% level of confidence. Using this new control variable improves the robustness of the results.

In column 4 of Table 4, we use a different combination of controls, already used before, and consider high-tech exports as a share of GDP. The coefficient of hybrid power sector reform is robust, positive and significant at the 5% level of confidence.

In column 5 of Table 4, we control for a new covariate which is monetary freedom, as an indicator of economic freedom. Monetary freedom can maintain price stability and preserve the country's wealth, and people can rely on market prices for the future. Investments, savings, and other longer-term plans can be made with more confidence. On the contrary, an inflationary policy acts such as an invisible tax and distorts prices, misallocates resources, raises the cost of doing business, decreases the international competitiveness of a country, and makes exports more expensive (Miller et al., 2019). Results show that the coefficient of hybrid power sector reform is robust, positive and significant at 5%. The magnitude of the coefficient of hybrid power sector reform does change a little, to as a 1 unit increase in hybrid power sector reforms leads to a 0.97 percentage points increase in the share of high-tech exports in total manufacture exports. Controlling for monetary freedom improves further the robustness of the IV results, although the Kleibergen-Paap F statistics becomes slightly inferior to 10.

Table 5 – IV estimates: controlling for lag values of high-tech exports

	High-Tech Exports (% of manufacture exports)			
	(1)	(2)	(3)	(4)
Second stage: Dependent variable is High-Tech Exports				
Power Sector Reform$_{t-3}$	2.040***	2.149***	2.077***	1.948**
	(0.747)	(0.749)	(0.515)	(0.780)
High-Tech Exports$_{t-1}$	0.017			-0.050
	(0.196)			(0.276)
High-Tech Exports$_{t-2}$		-0.071		
		(0.201)		
High-Tech Exports$_{t-3}$			-0.109	
			(0.172)	
R&D	-1.177	-1.318*	-1.442**	-1.226
	(0.789)	(0.697)	(0.569)	(0.833)
ICT goods imports	60.19	61.60	60.63	60.77
	(49.30)	(52.67)	(51.20)	(49.63)
Gov. Spending (EF)	-0.041**	-0.041***	-0.043***	-0.039**
	(0.016)	(0.016)	(0.015)	(0.017)
School Enrollment	0.015	0.025	0.037	0.026
	(0.047)	(0.042)	(0.036)	(0.046)
Fixed Cap. Formation	-0.346***	-0.374***	-0.383***	-0.360**
	(0.108)	(0.118)	(0.105)	(0.141)
Economic Freedom	0.108	0.112	0.103	0.117
	(0.088)	(0.095)	(0.100)	(0.095)
Oil Rents	-0.127**	-0.141**	-0.138***	-0.130*
	(0.063)	(0.062)	(0.038)	(0.076)
First stage: Dependent variable is Power Sector Reform$_{t-3}$				
PSR in neighbouring countries$_{t-3}$	0.067**	0.064***	0.079***	0.072***
	0.020	0.013	0.012	0.015
Observations	56	56	56	56
Number of ccode	7	7	7	7
Country FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Clustered SE	Yes	Yes	Yes	Yes
Kleibergen-Paap F-Stat	11.049	24.268	44.778	2.502

P-value in parenthesis. * Significant at the 10 percent level, ** Significant at the 5 percent level, *** Significant at the 1 percent level.

In column 6 of Table 4, we control for a new covariate which is investment freedom, as an alternative indicator of economic freedom. In an environment in which individuals and companies are free to choose where and how to invest, capital can flow to its best uses: to the sectors and activities where it is most needed and the returns are the greatest. As stated in Miller et al. (2019), State actions to redirect the flow of capital and limit the choice is an imposition on the freedom of both the investor and the per-

son seeking capital. The more restrictions a country imposes on investment, the lower its likely level of entrepreneurial activity. Results show that the coefficient of hybrid power sector reform is positive and significant at the 5% level of confidence. The magnitude of the coefficient of hybrid power sector reform only changes marginally, to 0.95 percentage points, and the Kleibergen-Paap F statistics remains higher than 10.

In column 7, 8, 9 and 10 of Table 4, we use different alternative combinations of controls. All results show that he coefficient of hybrid power sector reform is robust, positive and significant at the 5% level. The Kleibergen-Paap F statistics is greater than 10 in all regressions, allowing the reject the hypothesis of weak instrument, and the Durbin-Wu-Hausman test indicates no statistically significant difference between the OLS fixed effects and the IV estimators.

Finally, as an additional robustness check, estimations presented in Table 5 include lag values of high-tech exports in the set of control variables. Since high-tech exports may be partly explained by their past values, not including them may lead to an ommited variable bias. However, adding the lag value of the dependent variable has also proved to lead to biased estimates in short panels of up to 10 or 15 years (**?**). Since the time-dimension of data is greater than 40 years, such bias can be discarded and our instrumental variable approach maintained. Columns 1, 2 and 3 include the first, second and third lag of high-tech exports, respectively. Past values of high-tech exports do not appear to explain current values in a systematic way since the coefficients are statistically insignificant, but the relationship between power sector reforms and high-tech exports remains unaltered.

Table 5 column 4 presents the results when both power sector reforms and the first lag value of high tech exports are instrumented by the average power sector reforms of neighbouring countries and the second and third lag values of high-tech exports. The main result remains unaltered but the statistical significance decrease and the Kleibergen-Paap F statistics drops well below the threshold of 10. First-stage results show that the instrumentation of the first lag of high-tech export is problematic while that of power sector reform remains robust.

6 Conclusion

We contribute to the literature on the effects of economic reforms in developing countries by analyzing the effect of hybrid power sector reforms on high-tech exports in Arab League member states using a instrumental variable approach and by focusing on a region that has received relatively little attention. Previous literature has mainly focused on studying the effect of such power sector reforms on economic growth and

electricity generation and transmission, without considering the effects on technological change, a fundamental aspect of long-term economic development. Using a panel dataset, we estimate the effect of hybrid power sector reforms on high-tech exports among Arab League member countries. To reinforce the causal interpretation of this relationship, the empirical analysis uses an OLS approach, that include a broad set of covariates, complemented by an IV approach.

The OLS estimates confirm that there is a positive and significant relationship between power sector reforms and high-tech exports, while the IV approach uses the sum of neighboring countries power sector reforms to address the endogeneity issue and reinforce the causal interpretation of this relationship. The results indicate that there is a positive, significant, and robust effect of hybrid power sector reforms on technological improvement, proxied by high-tech export. The results remain positive and significant after controlling for a wide set of variables. Hence, our results point towards the absence of confounding effects that could lead to falsely attributing the effect of hybrid power sector reforms on high-tech exports.

While this paper establishes a relationship and provides evidences of a causal link between power sector reforms and high-tech exports among Arab League member countries, further research on this topic could concentrate on analyzing empirically the channels of transmission of such reforms to technological change using firm-level data. Creating an indicator that takes into consideration the enforcement of power sector reforms, and not only the *de jure* adoption of such reforms, would also prove interesting in the context of developing countries. Finally, further research could extend this work by measuring the effect of power sector reforms on other outcomes of technological change, such as private expenditure in R&D and patents.

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