The Natural Gas Sector in Post-Revolution Egypt

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Abstract

This paper assesses the economic implications of a situation in which Egypt increases the price of its gas exports to Israel to equalize the world price. This is motivated by the Egyptian revolution that toppled a government which was offering Israel preferential prices. The public discontent about the preferential treatment of Israel was recently reflected in several attacks on the pipelines that transfer the gas. Moreover, the paper also assesses the impacts of terminating the agreement in light of the April 2012 announcement of the Egyptian Natural Gas Holding Company of the termination of its contract to ship gas to Israel. A reduction of the deviation of export prices to Israel from the average world prices is simulated with the GTAP model and based on an updated version of the GTAP database that reflects the actual natural gas production, trade shares and cost structures in both countries. Results reveal that the Egyptian economy will enjoy welfare benefits from the abolishment of preferential treatment of Israel. However, the overall gas production in Egypt would decrease due to the removal of subsidized exports to Israel and supply to the domestic market as well as other destinations would increase after shrinking exports to Israel. The overall welfare gains would be driven by increases in export prices for gas that, despite the reduction in export volume, generate higher export revenues. The GDP would grow geared by the increasing returns to production factors especially in sectors with a high input share of gas such as the electricity; chemical, rubber and plastic products, and service sectors.

Keywords: *Natural gas, Egyptian revolution, Israel, GTAP model.*

JEL Classification: *C6, D1, D3, D6, E6, F1, Q4.*

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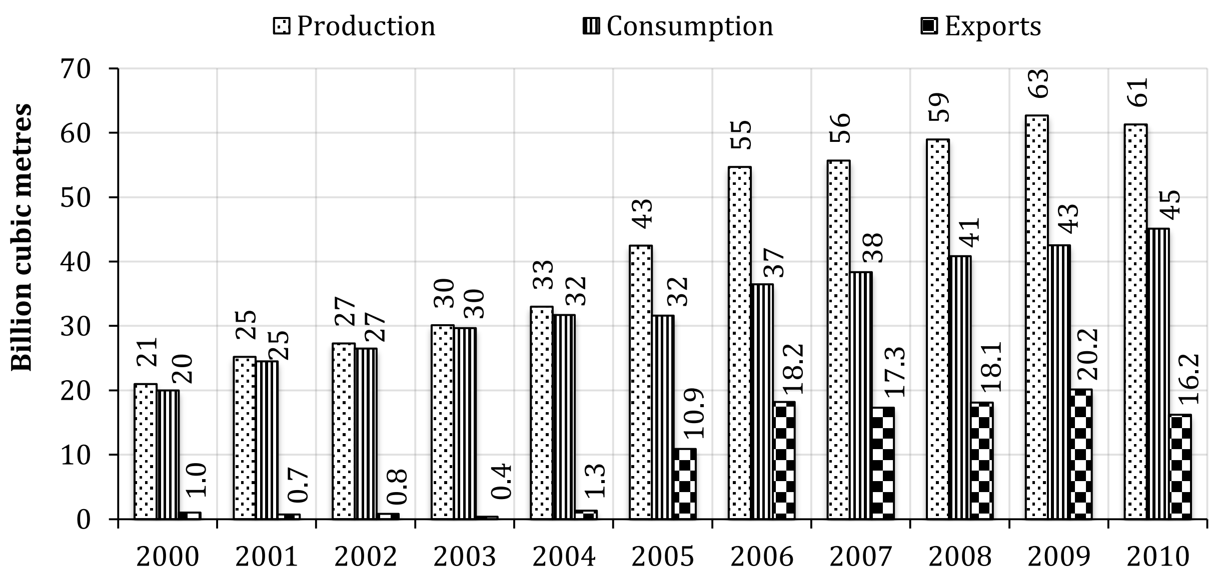
1 Introduction

The production of natural gas in Egypt has been on the rise, while the production of oil has been on a declining path since the mid-1990s (BP, 2011). Egypt is developing rapidly its large gas reserves, representing 15% of the total proved gas reserves in Africa in 2010. Gas production was approximating 61 billion tons in 2010, almost triple of what was produced ten years earlier (Figure 1). Until 2003, domestic consumption moved in tandem with production, leaving a very narrow room for exports. However, five major gas projects, which were developed between 2003 and 2004 (IMF, 2005) have raised annual gas production to the current level of more than 60 billion cubic meters (bcm). Therefore, Egypt evolved as a significant net exporter of gas in 2004 and was among the top 15 exporters of gas in the world in 2010 (BP, 2011).

Figure 1: Natural gas production, consumption and exports in Egypt (bcm, 2000 – 2010)



Source: BP (2011).

The importance of the natural gas sector in the Egyptian economy has been growing during the last decade. As shown in Table (1), it contributed 8% to total GDP at factor cost and nearly 56% to the value added of the mining sector on average over the period 2007 to 2010 (CAPMAS, 2011). The BMI (2009) forecasts suggest that gas exports would potentially reach 37 bcm by 2013; total production would reach about 87 bcm; and domestic consumption would reach 50 bcm.

On the consumption side of the economy, the total natural gas demand in Egypt has grown rapidly because the thermal power plants, which account for 65% of Egypt's total gas consumption, have switched from oil to gas (PMI, 2009). However, despite this rapid increase in the domestic consumption, exports of gas remain a major Egyptian priority. This is reflected by that, in 2010/2011, there was total implemented investment of US$ 38.8 billion, of which petroleum, natural gas and real estate activities constituted almost 30%, compared to only 2.7% and 2.5% directed towards agriculture and construction, respectively (African Economic Outlook, 2011).

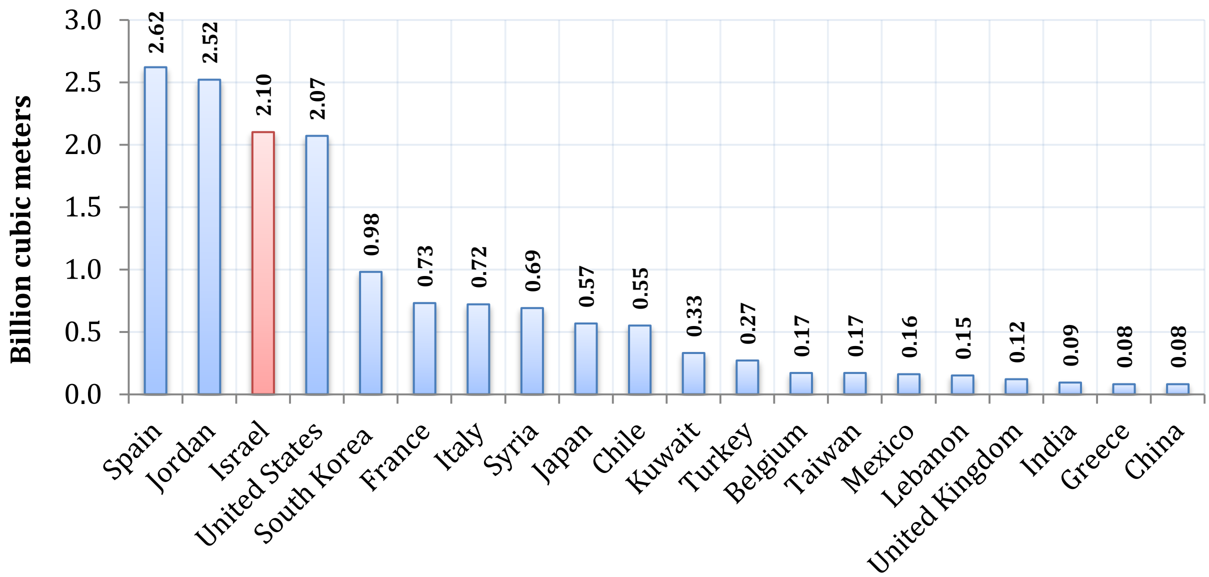
Table 1: The contribution of natural gas to the Egyptian Economy (2007 – 2010)

	Gas (billion Egyptian pound)	% Mining sector	% GDP
2007-2008	59.06	55.00	7.76
2008-2009	63.07	55.46	7.92
2009-2010	64.22	55.98	7.67
Average (2008 -2010)		55.48	7.78

Source: CAPMAS (2011).

The top four destinations of Egyptian gas exports in 2010 as shown in Figure (2) were Spain, Jordan, Israel, and USA, which received 17.3%, 16.6%, 13.8%, and 13.6%, respectively, and they all together accounted for 61.4% of total Egyptian gas export volume in 2010 (BP, 2011).

Figure 2: Destinations of Egypt's natural gas exports in 2010a



[a] Flows are on a contractual basis and may not correspond to physical gas flows in all cases.

Source: BP (2011).

Exports of gas to Jordan via an undersea pipeline started in 2003 during the first phase of the Arab Gas Pipeline project which feeds a power station in Aqaba, which was followed by extensions of the pipeline to Lebanon and Syria. The first annual shipment of gas exports to Jordan was at the value of US$ 60 million in 2003/04 (IMF, 2005). A 30-year agreement envisages export volumes rising from the 2003 level of about 1.1 bcm per year (bcmy) to 2.3 bcmy by 2010/11. In May 2004, an agreement for selling gas to Israel via an off-shore pipeline was approved. According to the agreement, the Israeli state-owned Israel Electric Corporation would buy 1.2 bcmy of Egyptian gas from July 2006, rising to 1.7 bcmy one year later under a 15-year contract, with an option to extend the agreement for a further five years (IMF, 2005).

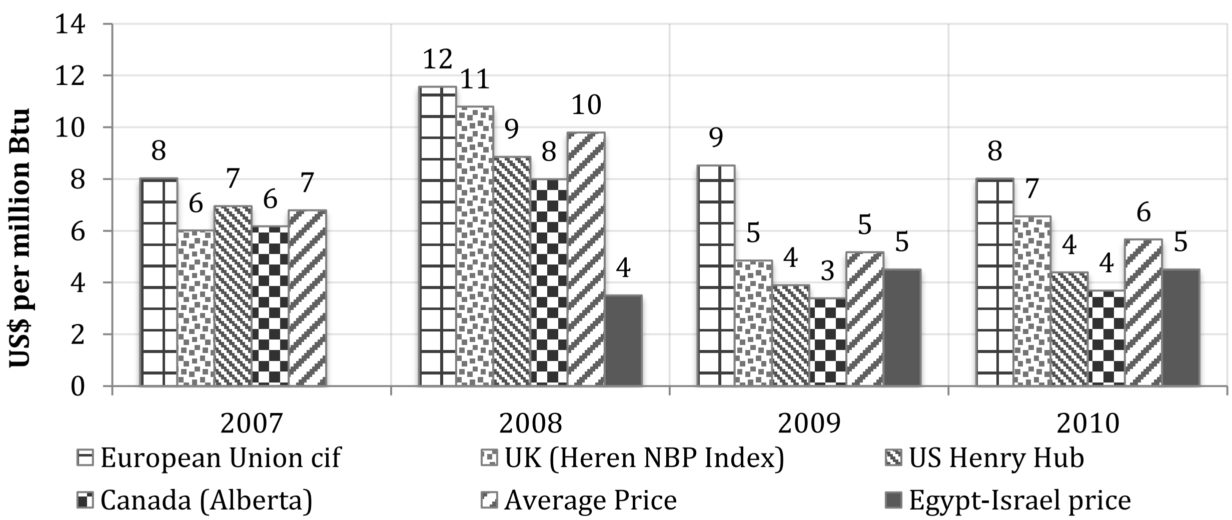
The agreement has effectively started in 2008, and since then Egypt is supplying Israel with about 40% of its domestically consumed natural gas**.** The gas is delivered through a pipeline that connects the Arab Gas Pipeline with Israel. Although this pipeline is not officially a part of the Arab Gas Pipeline project that connects Egypt to Jordan, Lebanon, and Syria, it branches off from the same pipeline in Egypt (Shaffer, 2011).

There is public discontent in Egypt against the sales of gas to Israel particularly after the January 2011 revolution as Israel pays below market prices for the natural gas it imports from Egypt (Ratner, 2011). Accordingly, there have been ten attacks on the pipeline since the eruption of the revolution, causing Israel's gas supply to be temporarily cut off (Afify and Fahim, 2011; Elyan, 2011). In addition, Israel is poised to become a natural gas producer and perhaps even a natural gas exporter provided the discoveries of major offshore natural gas reserves in 2009 and 2010 that were confirmed in the Mediterranean Sea near Israel (Ratner, 2011).

There is no detailed information available on the level of the preferential price paid by Israel and their differences from the world price of natural gas. However, according to Khadduri (2011), the initially agreed upon price was 3 to 3.5 dollars per million British thermal units (Btu). Khadduri (2011) also reports that, in August, 2009 the Israel Electric Corporation (the primary consumer of the exported gas) approved an adjusted price of 4 to 4.5 dollars per million Btu.

In order to quantify the difference between this price and the world price and to identify the gap between them, the price data of BP (2011) are used: (1) cif European Union, (2) UK Heren NBP Index, (3) US Henry Hub and (4) Canada (Alberta). Figure (3) compares the four prices, the average of these four prices, and the prices paid by Israel during the period 2007-2010, with the latter being those reported by Khadduri (2011).

Figure 3: Different international gas prices compared to those paid by Israel (2007 – 2010)



Sources: BP (2011) and Khadduri (2011).

Table (2) shows the average world prices, the preferential bilateral prices, and their absolute and percentage differences related to the world market price during the period 2007-2010. Khadduri (2011) shows two different ranges of prices for the pre and post-2009 periods, namely 3-3.5 and 4-4.5. However, for simplicity those shown in Table (2) and Figure (3) are only the highest within each range, i.e. US$ 3.5 per million Btu and US$ 4.5 per million Btu for the two periods, respectively.

Table 2: The world prices of gas against those paid by Israel price (2007 – 2010)

Prices (US$ per million Btu)	2007	2008	2009	2010
Average world price	6.79	9.80	5.16	5.66
Egypt-Israel price	-	3.50	4.50	4.50
Difference (Israel – average)	-	-6.30	-0.66	-1.16
% difference((Israel – average)/world *100)	-	-64.29	-12.79	-20.49

Sources: BP (2011), Khadduri (2011) and authors' calculations.

The highest difference in gas prices between the average world price and those paid by Israel is that of 2008, where the average world price was almost triple that paid by Israel, while in 2009 and 2010, Israel was paying about 13% and 20% below the average price for its imported gas from Egypt.

This paper analyzes the implications that an abolishment of preferential gas exports from Egypt to Israel might have on the Egyptian economy. Based on the current developments we analyze the following scenarios:

1) Egypt decides to increase the preferential export price of gas to Israel and (almost) equalizes it to that paid by Jordan and other importers, which is likely to happen as far as the related legal issues are cleared.
2) Egypt's gas exports to Israel cease completely and are redirected to other destinations. This may happen due to two very different reasons:

   (a) Egypt decides to opt from exporting gas to Israel at the end of the current contracts. This scenario reflects a very recent political development that was conveyed by several news agencies stating that "the head of the Egyptian Natural Gas Holding Company has said it has terminated its contract to ship gas to Israel because of violations of contractual obligations" (Aljazeera, 2012). In a statement by Aljazeera (2012), he mentioned also that "the Sunday's decision[3] was not political. This has nothing to do with anything outside of the commercial relations; Israel has not paid for its gas in four months". The later statement was denied by the Israeli foreign ministry spokesman according to Aljazeera (2012); or

(b) Israel operationalizes its new discoveries, reaches self-sufficiency in gas and hence displaces imports from Egypt.

Within the context of this paper we assume that scenario (2) is due to option (a) because option (b) relates to changes within the Israeli economy and this paper focusses on the problems from an Egyptian economy perspective.

The remaining parts of this paper are structured as follows: the following section provides an overview on the applied model and the rationale of its use for this study; it describes the database used, its aggregation, and the adjustments and reconciliation performed to reflect the real structure of the gas sector in terms of production, use and trade with particular focus on the Egyptian gas sector; and it describes the formulation of the main research questions raised in the previous section into experiments to be simulated in the described model. Section 3, shows and discusses the empirical results, which covers the impacts of the simulations on the trading sector, production, GDP and windup by highlighting the major welfare implications on the Egyptian people. The last section concludes and highlights the major policy implications.

2 Methodology

The problem we want to analyze has several dimensions. First, it has a microeconomic dimension as it evolves from one sector in the economy that influences other sectors such as the energy and electricity generation sector. Second, it has repercussions at the macroeconomic level through the significant contribution of the Egyptian gas sector to national GDP and external trade. Third, it has a multilateral trade dimension because in addition to Egypt, Israel and other countries are involved, with Israel being the focus of this study as an Egyptian trade partner and the rest of the world's regions being potential destinations for the gas diverted from Israel. Finally, the paper also has a strong political dimension which, despite its importance and likely dominance over other dimensions, is only briefly touched upon in our analysis.

[3] Sunday, April 22, 2012.

The decision about an analytical method was therefore made with the objective of covering as many as possible of these dimensions, while considering the data requirements availability. The global Computable General Equilibrium (CGE) model (Hertel, 1997) of the Global Trade Analysis Project (GTAP) is found suitable for the intended analysis for several reasons:

- First, it is a multi-regional model of world production and trade; hence, it can take into account the overall trade implications of changes in natural gas prices and traded quantities between Egypt and Israel, while considering any possible diversion to other partners.
- Second, it comes with a comprehensive global database that provides detailed information on 57 sectors and 129 regions covering all traded commodities and flexible possibilities of regional and sectoral aggregation. All the countries and commodities at the focus of this paper are included in the most recent release of GTAP database version 8 (Aquiar et al., 2012). Thus, trade implications for various sectors and regions of interest can be assessed.
- Third, the representation of trade in the GTAP model allows the simulation of a situation where trade flows across certain regions are reduced or eliminated. This advantage is particularly relevant to our second scenario.[4]
- Fourth, it allows for the assessment and decomposition of welfare effects of trade policies.
- Finally, the GTAP model and its global database have been widely used to study the effects of trade agreements and other trade policies, it is readily available to the public and the results reported in this study can be easily replicated.

2.1 Model Description

The GTAP modeling framework consists of a comparative static CGE model and a global database. The standard CGE model is based on neoclassical theory and commonly applied assumptions of constant returns to scale in production, perfect competition among firms, and product differentiation by economy of origin (i.e., the Armington assumption). The model is formulated and solved in GEMPACK software with a user friendly interface known

There is a single representative household for each region called the regional household. It collects its income from factor payments and tax revenues net of subsidies and spends it on

[4] Elaborated description of the regions and sector and their aggregation follows in section 3.2.

private household expenditure, government expenditure, and savings applying a Cobb-Douglas per capita utility function.

The private household maximizes its utility subject to its expenditure constraint, which is modeled as Constant Difference of Elasticity (CDE). It spends the generated income on consumption of both domestic and imported commodities based on a Constant Elasticity of Substitution (CES) aggregate. Imported goods are sourced from different regions according to a CES function as well. Taxes paid by the private household are commodity taxes for domestically produced and imported goods and the income tax net of subsidies. Government expenditures are allocated according to a Cobb-Douglas sub-utility function (Hertel, 1997).

Producers collect their income from selling consumption goods to consumers and intermediate inputs to other producers domestically and/or across borders. They spend this income on intermediate inputs, payments to production factors, and on taxes, and hence, satisfy the zero profit assumption. Every industry is assumed to produce a single output; Constant Returns to Scale (CRS) prevail in all markets.

Producers maximize profits by allocating two broad categories of inputs including production factors (value added) and intermediate inputs, which are combined according to a CES technology. The value added composite is a CES function of labor, capital, land and natural resources, while the intermediate composite is a Leontief function of inputs, which are sourced either from the domestic market or imports based on a CES function. Furthermore, the imported intermediate inputs are a CES composite of imports from different (Brockmeier, 2001). According to the standard factor market closure of the model that is applied in this paper, total supplies for land and labor are fixed for each region, but capital can cross regional borders to equalize changes in its rate of returns. The model distinguishes between factors that are completely mobile those earn the same returns regardless to their location, and those sluggish to adjust.

The model closes by assuming that the demand for investment in a particular region is savings driven and each region's savings contribute to a global pool of homogenous savings. The allocation of these savings among regions in response to investment demand is based on the relative rates of return to capital among regions.

Imports are distinguished by their origin through the employment of the Armington assumption which explains intra-industry trade of similar products. Accordingly, the GTAP database and model separate imported from domestically produced commodities which are combined in a second nest in the production tree, with the elasticity of substitution in this input nest being equal across all uses.

Final demand (government and private households) is composed of domestically produced and imported commodities and pays commodity taxes on imports to the regional household. Again imported and domestically produced commodities are combined in a composite nest for final demand with the elasticity of substitution between imported and domestically produced goods being equal across different demand components.

Import and export taxes as well as subsidy expenditures are modeled as price wedges between domestic and international prices of the traded commodities.

2.2 GTAP Database and Adjustments

This paper makes use of the most recent GTAP database version 8. This version has several features which make it particularly suitable for this study: (1) Dual reference years: 2004 and 2007; (2) Additional regional disaggregation as it comprises 129 regions; (3) 15 newly added regions including Israel and other countries in middle east such as Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and United Arab Emirates (Aquiar et al., 2012).

The dual reference year feature of this version of the GTAP database is considered an important feature, because it updates the information contained in the countries' IOTs to a more recent year, namely 2007. The contributed Israeli IOT (Siddig et al, 2011) for instance, has the year 2004 as a base, but having the 2007 update is particularly important in the context of this paper as it better reflects the recent state of the natural gas sectors in the Israeli and Egyptian economies, which have evolved strongly in the recent past. Therefore, we apply the 2007 reference year.

2.2.1 Database Aggregation

The 129 regions and 57 sectors of version 8 are aggregated to 45 regions and 40 sectors. For the regional aggregation, the following criteria are taken into account: (1) the importance of the country in the total production of natural gas at the global level, (2) the share of the country in the global gas trade, (3) the focus countries of the study, namely Egypt and Israel, and (4) the regions that are partnering the focus countries e.g. other importers of Egyptian gas besides Israel as well as other exporters (existing and potential) of gas to Israel besides Egypt. In addition, some related countries in the region with connection to the gas sector are also included such as Qatar, Iran and Saudi Arabia.

For the sectoral (commodity) aggregation the following factors are also used to reduce the standard GTAP 57 sectors 40: (1) the top 15 domestically sold commodities in Egypt, (2) the top 15 imported commodities in Egypt, (3) the top 15 exported commodities in Egypt, and (4) the top 15 users of gas as an intermediate at the global level. Some of the commodities are overlapping across the four categories; therefore, 38 commodities are selected according to this procedure. In addition, "vegetable and fruits" and "sugar and sugar cane" are removed from the aggregate "grain crops" - which is the default aggregated sector among the 10 sectors' aggregation - to reduce the heterogeneity of this aggregate, leading the considered number of commodities to be 40. Appendix (1) provides the complete list of commodities and their corresponding shares according to the described four criteria.

2.2.2 Database Adjustments

Exports of gas from Egypt to Israel started effectively in 2008. This implies that the GTAP database does not reflect recent quantities and values exported to Israel. Thus, in order to simulate changes in the Egyptian exports of gas to Israel, the database first needs to be updated. The empirical base for this update is a literature review of the recent structure of the gas sector in Egypt and Israel including production, trade and the cost structure. We rely on the comprehensive information provided by BP (2011) report that includes time series data on the approved reserves, production, consumption, trade and prices of gas. It also provides detailed information focusing on the year 2010 that breaks the gas movement down across partners at the global level. Additional information is collected from official sources in Egypt and Israel such as CAPMAS (2011) and ICBS (2011). Based on data availability, we chose to update the GTAP database to reflect the gas sector of Egypt and Israel as of 2010.

Two technical options for updating selected elements of the database exist: a manipulation of entries of the IOT with a subsequent procedure to balance the IOT, and a pre-simulation. In order to avoid the uncontrolled distribution of errors in an automatized balancing procedure, the option to reach an updated database by a pre-simulation was chosen for this study.

The pre-simulation is performed stepwise starting from the original GTAP database version 8 for the year 2007 and aggregated as described above. The entire process is shown in Figure (4), displaying the related variables and their changes across three (***to be clarified; see below) subsequent steps of the pre-simulation. The upper left hand panel shows the state of the original GTAP database compared to the target collected from the literature. For each step of the pre-simulation, the updated variables are shown and again compared to the target. The objectives of each step of the pre-simulation as well as the adjustments made and the outcomes achieved are summarized as follows:

Pre-simulation step 1:

(1) According to BP (2011), 40% of the domestically consumed gas in Israel in 2010 (2.1 bcm) is imported and sourced only from Egypt. The share of Egyptian gas in total Israeli gas imports, however, is only 0.001% in the GTAP database. The objective of the first pre-simulation step is to increase this share.

The importance of this step at the beginning of our adjustments evolves from the representation of trade based on the Armington assumption in the GTAP model, resulting in the so called “small shares stay small” property (Hanslow, 2001), which would not allow Egypt to reach a substantial share in Israeli imports in response to whatever change in relative prices without any modification of the Armington function. Kuiper and van Tongeren (2006) develop an approach to overcome this problem and apply it within the GTAP framework.[5] They apply a gravity equation to estimate trade shares that would prevail after a reduction of trade barriers. Afterward they use these estimated trade shares to calculate import augmenting shifters for the Armington functions.

We apply the approach developed by Kuiper and van Tongeren to update the share of Egypt in Israeli gas imports based on real world data for 2010 provided by BP (2011). Specifically, we simulate an augmentation of Israeli imports of gas from Egypt by 61.5% which is performed by setting the (ams) parameter in the import demand equation of the model[6] to increase by 61,5%. This results in the share of Egypt in Israeli imports of gas increasing from 0.001% to 99.7% (Figure 4, step 1).

Pre-simulation step 2:

(2) According to the real world data, imported gas in Israel in 2010 represents 40% of domestic gas consumption gas. In quantity terms, this is 2.1 bcm and in value terms

[5] Refer to Kuiper and van Tongeren (2006) for an extended literature review and further details.

[6] Equation IMPORTDEMAND # regional demand for disaggregated imported commodities by source (HT 29) # (all,i,TRAD_COMM)(all,r,REG)(all,s,REG) qxs(i,r,s) = -ams(i,r,s) + qim(i,s) - ESUBM(i) * [pms(i,r,s) - ams(i,r,s) - pim(i,s)];

this is US$ 431.14 million (Appendix 2). In the database, however, this value is only US$ 0.51 million and represents only 2.9% of total domestic consumption. The objective of the second pre-simulation step is to increase the share of gas imports in total domestic use as well as total domestic use.

To update this value, similar approach to that of the (*Pre-simulation step 1)* was followed but on the top of the results obtained from the first simulation i.e. a new version is created based on the output of the first version. Afterwards, the shock was introduced, which augments in addition to the (ams) parameter of the import demand function, the domestic use (qfd) of gas in Israel by its major users in the industry demand equation of the model after exogenizing it in exchange of the augmenting technical change parameter (afall).[7] This combination therefore, would assure that, the increasing imports will not reduce the amount produced domestically. The outcome of this simulation is represented by the outcome of step (2) of Figure (4). It was not possible to achieve the US$ 431 million target through this shock alone and the maximum increase in the imports from Egypt augmenting shifter was 4%, however, Israeli imports increase to US$ 89 million and the share of imports in total use in Israel increases from 4.3% to 34%.

Pre-simulation step 3:

(3) The Egyptian production of gas was 55.7, 59.0, 62.7, and 61.3 bcm in 2007, 2008, 2009, and 2010, respectively (BP, 2011); being equivalent to US$ 13.7, 21.0, 11.7, and 12.6 billion.[8] However, the GTAP database shows only a value of US$ 9.3 billion. Therefore, the first objective of third pre-simulation step is to increase Egyptian gas production.

(4) On the exports side, Figure (1) shows that, 26.5% of the total domestic production of gas in Egypt is exported in 2010. Out of this share, 2.10 bcm is exported to Israel, which accounts for 13.8% of the total Egyptian exports of gas in the same year. The GTAP database however, shows only 0.001% instead (2.6% after pre-simulation steps 1 and 2). Hence, the second objective of the third pre-simulation step is to increase Egyptian gas exports to Israel.

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[7] Equation INDDOM # industry j demands for domestic good i (HT 32) #
(all,i,TRAD_COMM)(all,j,PROD_COMM)(all,s,REG) qfd(i,j,s) = qf(i,j,s) - ESUBD(i) * [pfd(i,j,s) - pf(i,j,s)];

[8] Details on the quantity (bcm) conversion into values in US$ billion are provided in Appendix (2).

(5) The Israeli domestic gas production is US$ 646 million, of which only US$ 16.8 million is reflected in the GTAP database. Hence, the third objective of the third pre-simulation step is to increase Israeli gas production.

(6) The structure of Egypt's bilateral gas exports to countries other than Israel according to the base data of GTAP doesn't reflect that of the BP (2011). Therefore, the fourth objective of the third pre-simulation step is to adjust Egypt's exports to the different regions so that it reflects the BP (2011) shares including those to Israel of 13.8% of the total Egyptian exports of gas.

The major components of the third pre-simulation step are summarized in the following, while their outcomes against the targets are shown in the bottom-right box (output of step 3) of Figure (4):

(a) Augmenting: (1) factor use by the gas sector in Egypt (afeall), (2) factor use by the gas sector in Israel(afeall), (3) use of gas as intermediate in Israel (qfd), and (4) use of gas as intermediate in Egypt (qfd);

(b) Reallocating Egyptian exports across different destinations based on BP (2011) data on natural gas movement (ams parameter); and

(c) Eliminating: Egypt's exports to non-recipient countries according to the BP (2011) using the percentage change in export quantities (qxs).

Figure 4: Data adjustments to generate a base for simulations

GTAP Base (Aquiar et al. 2012)

Variable	Current	Target
Israel imports US$ million	0.51	431
Israel share in Egypt's exports	0.001%	13.8%
Israel imports/use %	2.9%	40%
Israel output US$ million	16.8	646
Israel share of gas in the cost structure of electricity	0.19%	10.6%
Egypt share in Israel's import	7.1%	100%
Egypt output US$ million	9300.2	12591
Egypt export US$ million	3381.5	3337
Egypt export/output %	36.4%	26.5%

1 Augmenting Israeli imports of gas from Egypt by 61.5%

Updated data using step (1) simulation

Variable	Current	Target
Israel imports US$ million	0.75	431
Israel share in Egypt's exports	0.02%	13.8%
Israel imports/use %	4.3%	40%
Israel output US$ million	16.5	646
Israel share of gas in the cost structure of electricity	0.19%	10.6%
Egypt share in Israel's import	99.7%	100%
Egypt output US$ million	9300.3	12591
Egypt export US$ million	3381.7	3337
Egypt export/output %	36.4%	26.5%

2 Augmenting Israeli imports of gas from Egypt by 4% and Augmenting the intermediate use of Gas in Israel by its major users

Updated data using step (2) simulation

Variable	Current	Target
Israel imports US$ million	89.1	431
Israel share in Egypt's exports	2.6%	13.8%
Israel imports/use %	33.8%	40%
Israel output US$ million	174.5	646
Israel share of gas in the cost structure of electricity	4.37%	10.6%
Egypt share in Israel's import	99.7%	100%
Egypt output US$ million	9325.7	12591
Egypt export US$ million	3397.4	3337
Egypt export/output %	36.4%	26.5%

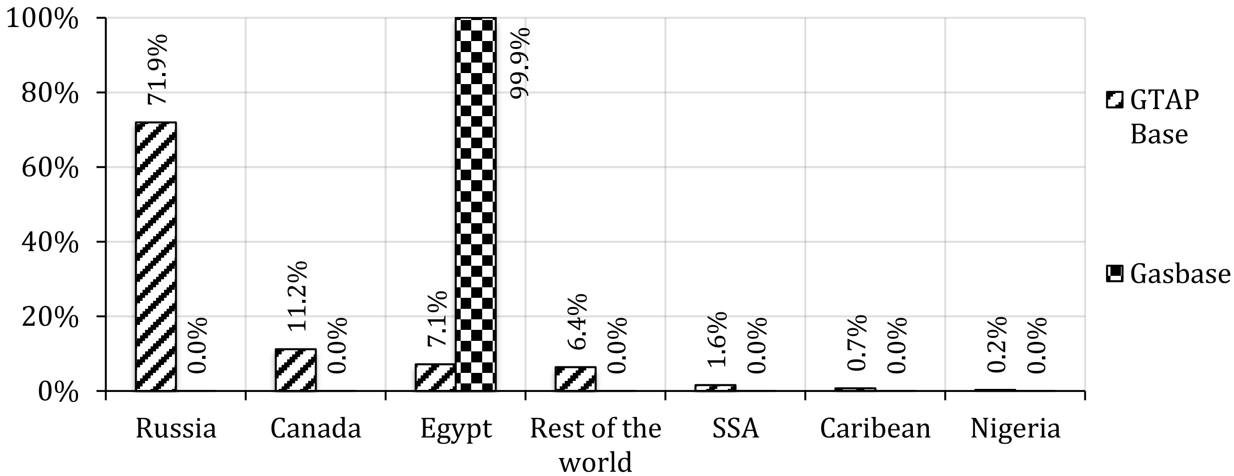
3
- Augmenting: (1) factors use in Gas sector in Egypt, (2) factors use in Gas sector in Israel, (3) intermediate use of Gas in Israel, (4) intermediate use of Gas in Egypt
- Reallocating the Egyptian exports,
- Eliminating: (1) Israel's exports to itself, and (2) Egypt's exports to non-recipient countries.

Updated data using step (3) simulation

Variable	Current	Target
Israel imports US$ million	442.2	431
Israel share in Egypt's exports	13.1%	13.8%
Israel imports/use %	39.7%	40%
Israel output US$ million	670.7	646
Israel share of gas in the cost structure of electricity	9.85%	10.6%
Egypt share in Israel's import	99.9%	100%
Egypt output US$ million	12555.4	12591
Egypt export US$ million	3368.0	3337
Egypt export/output %	26.8%	26.5%

Figure (5) shows a comparison between the share Egypt has in the total Israeli imports in GTAP database and the updated database (Gasbase), while Figure (6) compares the shares the different destinations of Egypt's exports of gas have in the GTAP database and the updated database in comparison to those of BP (2011) for the year 2010.

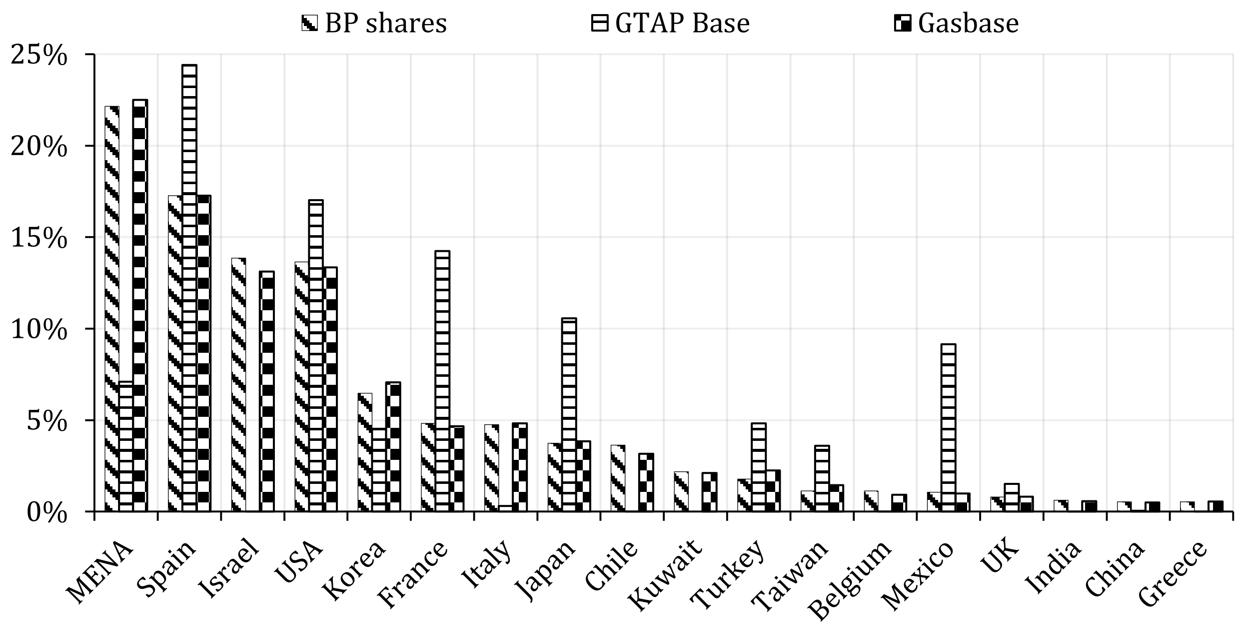
Figure 5: Shares of Israel's sources of gas imports in the GTAP database and the updated database (Gasbase)



Sources: Aquiar et al. (2012); Authors.

Figure (5) shows that 72% of Israeli imports of gas were sourced from Russia with the Egyptian share being only 7% in the original GTAP database. However, the pre-simulation results confirm their adjustment to the desired state that is compatible with the shares that are calculated based on BP (2011) natural gas movement data. Figure (6), focusses on the shares of each destination of Egypt's export of gas and shows how close the updated shares are to those of BP (2011).

Figure 6: Shares of the destinations of Egypt gas exports (GTAP base and updated base)



Sources: Aquiar et al. (2012); BP (2011); Authors.

2.3 Scenarios

To simulate our designated scenarios, the relevant variable for scenario (1) is the FOB price of gas supplied from Egypt to Israel, which is an endogenous variable. Therefore, it should be swapped by an exogenous variable that has similar dimensions and influence, so that we can simulate various price levels. The chosen swappable variable is the destination specific change in subsidy on exports of gas from Egypt to Israel. Hence, the price change would in effect be equivalent to an export subsidy change, which requires the level of this particular subsidy to be equivalent to the intended price change in the baseline data. Accordingly, we start each of our price change sub-scenarios by generating a new database through a pre-simulation adjustment according to an approach developed by Malcolm (1998). Afterward, each one of the two price simulations is performed by increasing the level of price paid by Israel for the Egyptian gas to the level that removes the corresponding subsidy. The outcome of the “Altertax”pre-simulation of Malcolm (1998) that prepares the database according to 2009 gas price is shown in Figure (7).

Figure 7: Updating the gas exports subsidies using "Altertax" pre-simulation

The updated GTAP data (Output of step 3 in Figure 4)

Variable	*Current*	*Target*
Israel imports US$ million	442.2	431
Israel share in Egypt's exports	13.1%	13.8%
Israel imports/use %	39.7%	40%
Israel output US$ million	670.7	646
Israel share of gas in the cost structure of electricity	9.85%	10.6%
Egypt share in Israel's import	99.9%	100%
Egypt output US$ million	12555.4	12591
Egypt export US$ million	3368.0	3337
Egypt export/output %	26.8%	26.5%

Adjusting the export taxes and subsidies by applying Altertax pre-simulation. It adds a subsidy to gas exports from Egypt to Israel

Updated subsidy data using Altertax simulation

Variable	*Current*	*Target*
Israel imports US$ million	442.2	431
Israel share in Egypt's exports	13.1%	13.8%
Israel imports/use %	39.7%	40%
Israel output US$ million	670.7	646
Israel share of gas in the cost structure of electricity	9.85%	10.6%
Egypt share in Israel's import	99.9%	100%
Egypt output US$ million	12633.1	12591
Egypt export US$ million	3368.3	3337
Egypt export/output %	26.7%	26.5%

Two sub-scenarios following FOB world price changes are carried out based on the three price differences of Table (2). We select the 2008 situation with the highest price difference and the 2009 situation with the lowest price difference. The 2010 price falls in between and for simplicity, no separate experiment is included for that in this paper. Moreover, , the third scenario builds on 2008 to allow comparing its impact to that caused by the highest difference between the preferential and world price, which was prevailing in 2008. It is important to mention that, the differences between the world price of gas and that paid by Israel are considered here in relation to those paid by Israel, so that they directly reflect the equivalent subsidy that should be put on the top of the preferential price to equalize it to the world price.

Scenario (2) assumes the elimination[9] of exports of gas from Egypt to Israel. To simulate this scenario the suitable variable to fix is export sales of gas from Egypt to Israel, which is also an endogenous variable that needs to be swapped. Again this variable is swapped with the destination specific change in subsidy on export of gas from Egypt to Israel for both consistency and relevance reasons.

Based on the previous technical description, the scenarios simulated and discussed in this paper are the following:

[9] Note that, the complete elimination of the exported quantities causes model instability and reduces the accuracy of the obtained results. Therefore, the exported quantities of gas from Egypt to Israel were reduced by 96.5% instead of 100%.

(1) *Scena1-08: increasing the FOB price of gas exported from Egypt to Israel to equalize the average world price in 2008.*
(2) *Scena1-09: increasing the FOB price of gas exported from Egypt to Israel to equalize the average world price in 2009.*
(3) *Scenario2: eliminating exports of gas from Egypt to Israel, considering the 2008 export prices of gas.*

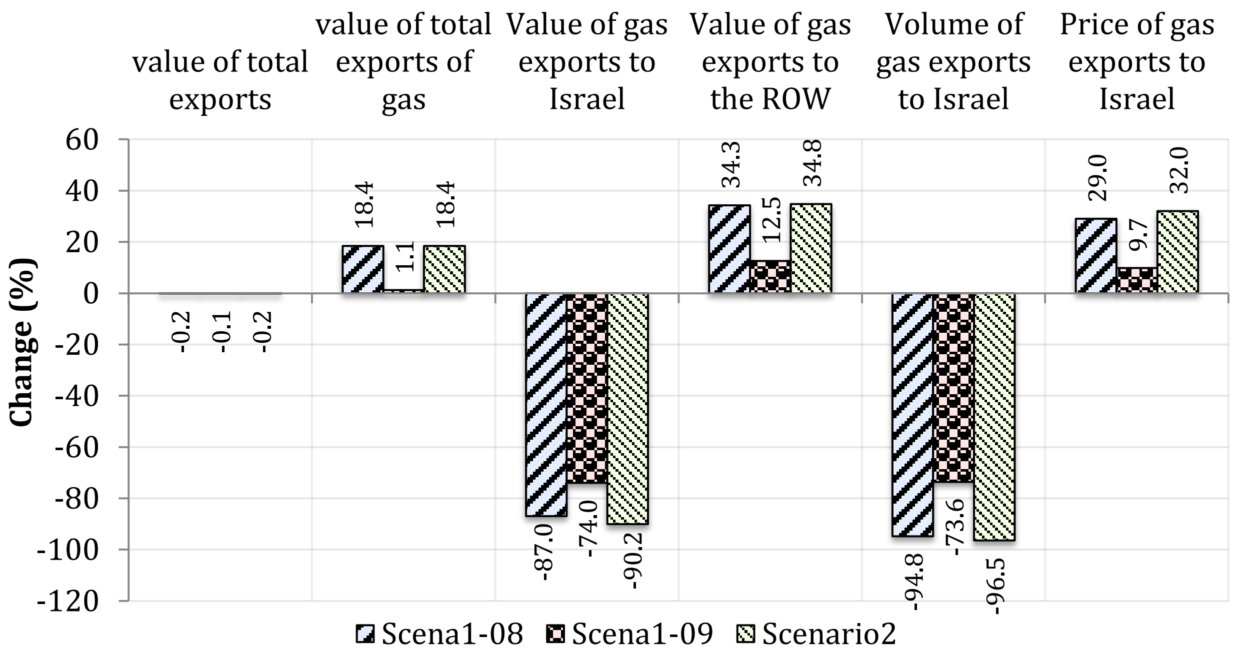
3 Results and Discussion

In this section, the results obtained from the three scenarios are shown and discussed. We present the results of the three scenarios together in order to compare the magnitude of their impact on the different components of the economy. Results are discussed in an order that follows the shock, i.e. the impact on exports and trade will be first, followed by production, GDP and its components, and closed by discussing the welfare implications.

3.1 Impacts on Trade

Exports of goods and services contributed 33%, 25% and 21% to the Egyptian GDP in 2008, 2009, and 2010, respectively (World Bank, 2012). The impact of our three simulations on Egypt's exports is shown in Figure (8). They will reduce gas exports to Israel, which translates in very small reductions in the total value of Egypt's exports despite the increase in the total exports of gas. What is important in these results is that the huge declines in the exports of gas to Israel do not cause reductions in the total exports of gas; however, Figure (8) shows increases in total exports of gas reaching 18% under Scenario2, and Scena1-08 and 1% under Scena1-09. At the same time, the exported gas quantities did not increase, however the results reports volume changes (dvol) of -124, -1 and -127 reductions due to Scena1-08, Scena1-09 and Scenario2, respectively. These increases in value terms are mainly due to the reallocation of exported gas towards other countries (regions) that pays more as reflected by the increases in the price index of merchandise exports from Egypt by 0.44%, 0.06%, and 0.45% due to Scena1-08, Scena1-08, and Scenario2, respectively (Figure 10).

Figure 8: Impacts of the gas scenarios on Egypt's exports (%)



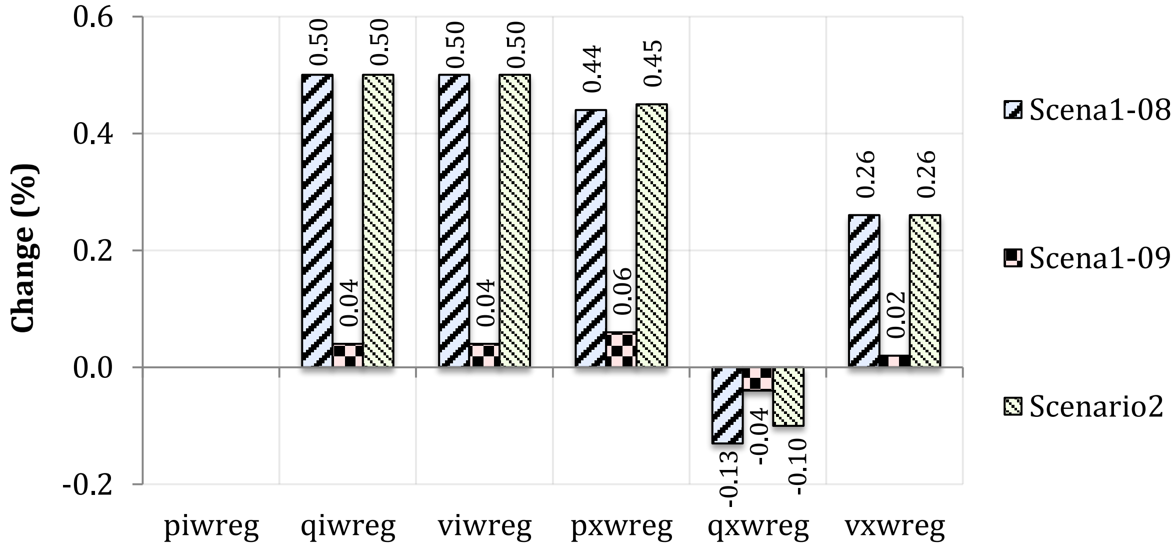
Source: Own calculations.

Despite the elimination of 96.5% of the quantity of gas exports from Egypt to Israel according to Scenario2, the change in value terms is only 90% (Figure 9), which is explained by the huge increase in the price of export (fob price) by 32%, therefore, the remaining 3.5% of exports can generate higher value of exports to Egypt than expected.

The exports of gas to the rest of the world (ROW: countries other than Israel) are also shown in Figure (9), which would increase by 34.3%, 12.5%, and 34.8% due to the three scenarios, respectively. These increases outweighs the decreases in the exports of gas to Israel as only 13.5% of the Egyptian exports of gas destines Israel in the baseline, compared to 86.5% that destines the ROW.

At the macro-level, the impacts of the three simulations on the overall Egyptian trade balance are US$ -144 million, US$ -11 million, US$ -145 million, respectively. These can be explained by the development of the total merchandise exports (volume – qxwreg and price index – pxwreg), the total merchandise imports (volume – qiwreg and price index – piwreg), and their respective values (vxwreg and viwreg) as shown in Figure (10).

Figure 9: Impacts on Egypt's merchandise trade (%)



Source: Model results.

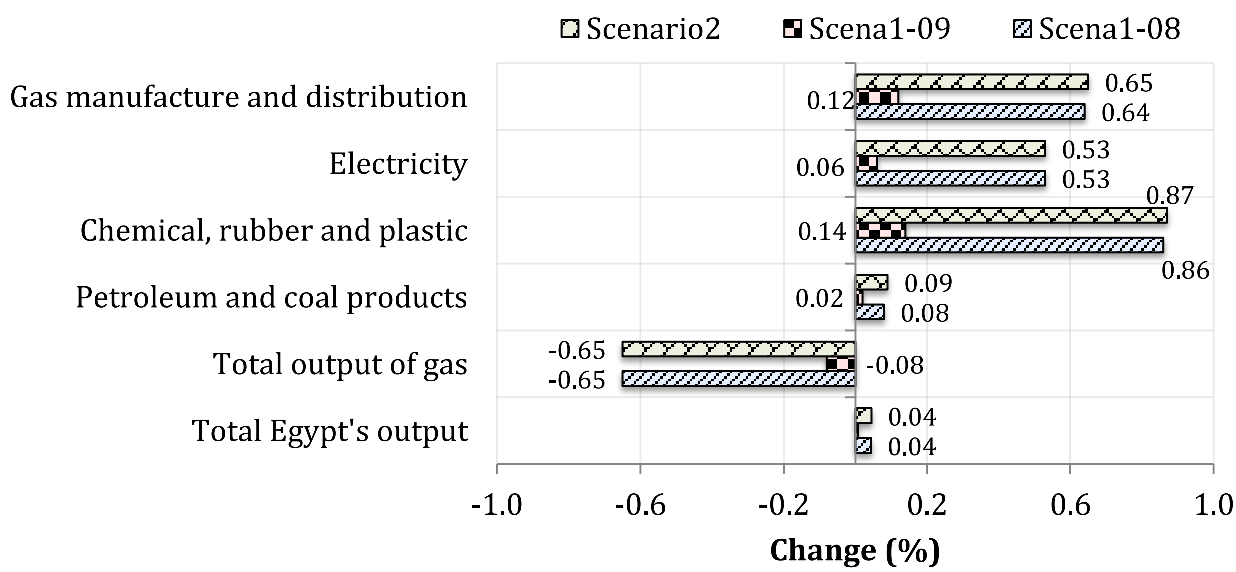
The three scenarios didn't change merchandize import price indices, but increases are shown in the overall imports; however in the exports side, despite the decreases in volumes, values have shown increases of 0.26%, 0.02%, and 0.26% due to Scena1-08, Scena1-08, and Scenario2, respectively, which contributes to making the resulting deficit in the trade balance smaller.

At the commodity level, most of the commodities witness decreases in their exports except three commodities. These are gas, which would increase by 17.6%, Gas manufacture and distribution increasing by 4.3%, and Chemical, rubber, and plastic products, which would increase by 1.1%, all the changes are due to Scenario2.

3.2 Impacts on Domestic Production

Figure (11) show the impact of the three gas scenarios on the output of gas, the overall Egyptian output of commodities, and the output of the major users of gas in Egypt. The three gas scenarios decrease the output of gas with Scenario2 causing the strongest effect, followed by Scena1-08, while Scena1-09 causes the minimal impact. The overall reduction in the output of gas is due to the nature of the three simulations as subsidy-removers because the price differences between Israel and other destinations are introduced in the model and database as subsidies, which would anyhow reduce the producers' motivation in the gas sector. Another cause of the decrease in output is the supply effect. The total exported gas as shown in the previous subsection decreases after the three gas scenarios in volume terms, which increases the domestic supply of gas and hence leads the supply price to fall by 1.29%, 0.21%, and 1.31% due to Scena1-08, Scena1-09, and Scenario2, respectively.

Figure 10: Impact of the gas scenarios on domestic production



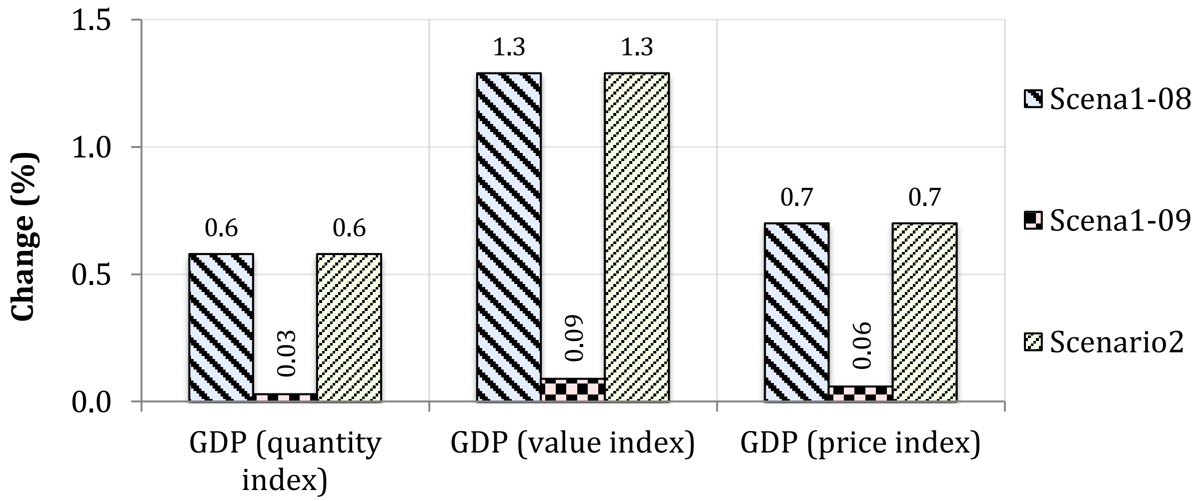
Source: Model results.

In contrast to the reduction in gas output under the three gas scenarios, overall output in Egypt slightly increases as shown in Figure (11). The reallocation of the productive resources among sectors resulting from lower gas prices leads to different changes in the sectoral output. The major users of gas witness increases in their output, which together with other sectors weight out the sectors with declining outputs. The major users of gas as intermediate input in Egypt are Petroleum and coal products (uses 20% of the intermediate gas demand), Chemical, rubber and plastic products (12%), Electricity (54%) and Gas manufacture and distribution (3%). The four sectors together consume 89% of the intermediately used gas in the Egyptian economy. Therefore, their output witnesses relatively high increases and together with other related sectors, they led to the overall output increases shown in Figure (11) due to the three simulated scenarios.

3.3 Impacts on GDP

Figure (12) shows the percentage changes in the Gross Domestic Product (GDP) indices due to our three gas scenarios, where all are increasing. The GDP value formula in the model is represented as the values of the different GDP components from the expenditure side including final consumption, exports, and investment less import each multiplied by its percentage changes in quantities and prices terms. Therefore, the GDP value as shown in Figure (12) is in effect the result of adding up the percentage changes in price and quantity indices.

Figure 11: Impacts on the Egyptian GDP (%)



Source: Model results.

Breaking down the GDP to its components from the expenditure side and for simplicity considering only the results of Scenario2, we note that government consumption witnesses the highest increase (1.43%) followed by private consumption (1.36%), investment demand (1.0%) and exports (0.26%), while imports would also increase 0.5%. The latter two components explain the US$ -145 million overall deficit in the Egyptian trade balance caused by the same Scenario2.

Exploring the impact of the same scenario from the sources side of the GDP, which comprises (a) net factor income, (b) net tax revenue, and (c) value of depreciation reveals increases by 0.69%, 7.67%, and 0.52% for each component, respectively. This explains the previous increases in the consumption side of the GDP and particularly in the government consumption as its net taxes revenue will increase as a result of the removal of subsidies on the exports of gas to Israel. Net tax income represents 8.8% of GDP in the base, and this share will increase to 9.4% after eliminating gas exports to Israel according to Scenario2.[10] By further digging in the factor income components that account for 81% of GDP, results of Scenario2 show decreases in the use of natural resources by 4.63%, capital by 0.27% and labor by 0.1% in the gas sector. However, uses of primary factors would increase in 36 other sectors led by Mining and Extraction; Chemical, rubber, and plastic products; Public Administration, Defense, Health and Education; and Gas manufacture and distribution, where the highest percentage changes in the total factor income are recorded. However, in value terms, the highest income generated from factor use is witnessed in the sector ordered as (1) Public Administration, Defense, Health and Education; (2) Other Services; (3) Trade; (4) Construction; and (5) Communications due to their larger size in the overall economy relative to the other sectors.

3.4 Impacts on Welfare

The welfare impact of our three scenarios is measured using the money metric Equivalent Variation (EV). The EV measures the welfare impact of a policy change in monetary terms and it is defined as the amount of income that would have to be given to (or taken away from) the economy before the policy change to leave the economy as well off as the economy would be after the policy change (Andriamananjara et al., 2003). If the EV for a policy simulation is a positive number, it implies that the policy change would improve economic welfare. The EV of a policy change consists of two major components: changes in allocative efficiency and terms-of-trade effects. Allocative efficiency contributions arise when the allocation of productive resources changes due to policy changes; terms-of-trade contributions arise from changes in the prices received from an economy's exports relative to the prices paid for its imports. [11] In addition, the EV policy change also comprises the changes in the price of the investment goods (I-S component).

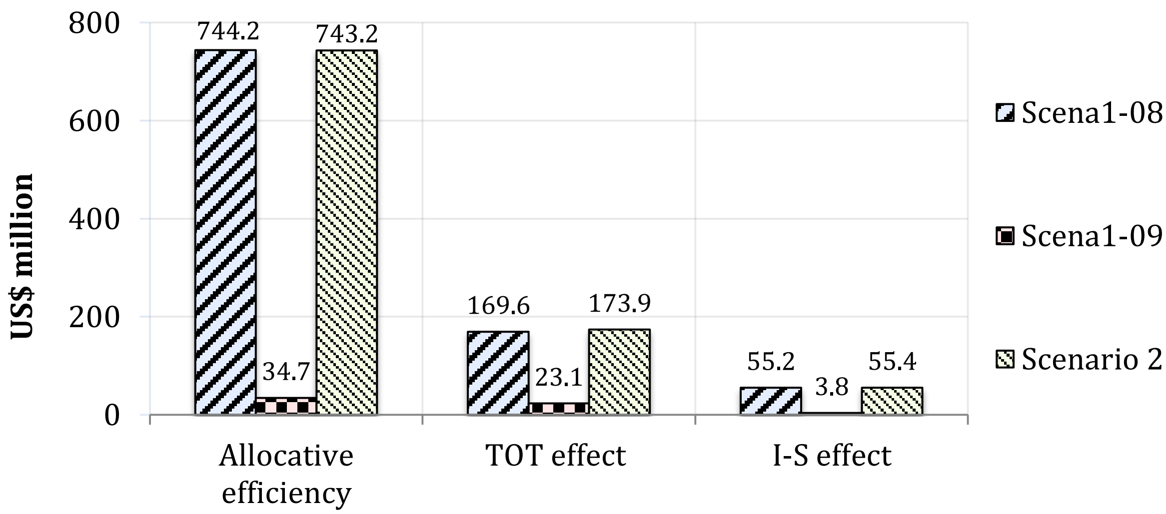
Scena1-08, Scena1-09, and Scenario2 are found to generate overall welfare gains to Egypt of US$ 969 million, US$ 61 million and US$ 973 million. In relative terms, these welfare changes constitute 1.01%, 0.06% and 1.02, respectively of the baseline household consumption. By decomposing the welfare effect as depicted by the EV in the model and

[10] Appendix (3) provides details on the base and updated values as well as different changes and shares on the GDP values from the expenditure and source sides.

[11] It is assumed in GTAP model that, each region has large enough market power to be able to affect world price by changing its policies.

shown in Figure (13), it is clear that the sources of gains are mainly of the reallocation of resources towards productive sectors, increases in the export prices relative to those of imports, and slightly from the investment and savings.

Figure 12: Welfare impact as depicted by the EV components



Source: Model results.

The gain in allocative efficiency is explained by the reallocation of production factors across sectors as described in the previous section. By breaking down the allocative efficiency impact to its components by commodity, it shows that 97% of the gain due to Scena1-08 and Scenario2 and 95% of the gain due to Scena1-09 was reaped from the gas commodity. Moreover, similar percentage shares are also obtained from the three scenarios considering further breakdown of the allocative efficiency impact according to tax types, where export taxes (subsidy removal) are the main source of gains.

4 Conclusions

In this paper, the politically sensitive issue of the Egyptian gas exports to Israel is analyzed. This issue became more debated after the Egyptian revolution that toppled a government that was presumably offering Israel preferential prices for its imports of the Egyptian natural gas as reflected in the current agreement on that, which has started gas shipment to Israel in 2008. The public discontent about that was reflected in several attacks on the pipelines that transfer the gas to Israel since January 2011. Moreover, a very recent development was the decision of the Egyptian Natural Gas Holding Company of the termination of its contract to ship gas to Israel because of violations of contractual obligations.

This paper focuses on the economic part of this multi-dimensional and complex story. It investigates the sensitivity of the Egyptian economy at large to changes in the price that Israel pays for its imports of gas from Egypt, and whether or not increasing these prices to the level paid by other partners would improve the welfare and generate economic gains that could outweigh the associated political instability and contractual disapprobation.

As prices are found to vary differently since the beginning of this agreement, three different year prices are considered, namely 2008, 2009, and 2010 in comparison to the average world prices. The prices variation from the average world prices are simulated in GTAP model scenarios that convert them in subsidy equivalent. The simulation scenarios are introduced to an updated version of GTAP database that became as compatible as possible to other related data sources that focuses on the natural gas production, trade shares and cost structures in both countries.

Results reveal that the Egyptian economy will reap as substantial welfare benefits as larger as the prices differences in the agreement from world prices. This however, results in a reduction in the overall gas production in Egypt due to subsidy removal and increasing supply in the domestic market due to the reductions in exports. The gains would mainly be driven by the increase in the exports price indices that despite the reductions in export volumes, generate higher export revenues for the economy. On average 96% of the welfare gains accrue from the gas sector motivated by the increasing prices of exports and the removal of the corresponding export subsidies.

The GDP would also improve geared by the increasing returns to production factors in sectors other than gas and mainly in the electricity; chemical, rubber and plastic products; and some major service sectors. This would basically increase income and hence final demands that boosts the overall GDP despite slight increases in imports with the latter generating slight deficits in the country's trade balance.

Similar outcome could also accrue to the Egyptian economy if exports of gas to Israel are to be stopped. As far as the price paid by Israel lies below the world price, Egypt would anyhow benefit from the reallocation of its gas to other destinations. This is particularly possible as other destinations are already exist and importing the Egyptian gas; hence no further infrastructure development would be required such as pipelines construction that might make the reallocation difficult or costly.

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6 Appendix

Appendix 1 : Criteria considered in the aggregation of commodities

Top 15 exported commodities in Egypt	Share
Transport nec	19.9%
Gas	9.0%
Petroleum, coal products	8.5%
Chemical, rubber, plastic prods	6.2%
Wearing apparel	3.8%
Ferrous metals	3.6%
Metals nec	3.6%
Business services nec	3.6%
Textiles	3.4%
Air transport	3.4%
Communication	2.8%
Oil	2.7%
PubAdmin/Defense/Health/Education	2.6%
Machinery and equipment nec	2.5%
Recreation and other services	2.5%

Top 15 imported commodities in Egypt	Share
Machinery and equipment nec	15.2%
Chemical, rubber, plastic prods	11.9%
Motor vehicles and parts	6.0%
Business services nec	5.1%
Ferrous metals	4.9%
Petroleum, coal products	4.4%
Wheat	4.2%
Textiles	3.8%
Electronic equipment	3.5%
Wood products	2.7%
PubAdmin/Defense/Health/Education	2.7%
Transport equipment nec	2.6%
Oil	2.2%
Paper products, publishing	2.2%
Vegetable oils and fats	2.0%

Top 15 domestically sold com. in Egypt	Share
PubAdmin/Defense/Health/Education	9.1%
Construction	8.2%
Trade	6.0%
Petroleum, coal products	5.7%
Transport nec	5.5%
Oil	4.5%
Food products nec	4.1%
Wearing apparel	3.9%
Textiles	3.8%
Gas	3.6%
Communication	3.2%
Business services nec	3.2%
Electricity	3.1%
Chemical, rubber, plastic prods	2.7%
Vegetables, fruit, nuts	2.6%

Top 15 intermediately demanders of gas Globally (sectors)	Share
Electricity	33.0%
Petroleum, coal products	25.8%
Chemical, rubber, plastic prods	14.2%
Gas manufacture, distribution	5.4%
Oil	5.2%
Transport nec	4.6%
Gas	4.4%
Ferrous metals	1.4%
Minerals nec	1.0%
Mineral products nec	1.0%
Trade	1.0%
Business services nec	0.7%
PubAdmin/Defense/Health/Education	0.5%
Paper products, publishing	0.3%
Communication	0.3%

Appendix 2 : Converting gas production data (bcm) into values (US$ million)

The gas data that is provided by BP (2011) are in volume terms (bcm). This needs to be converted to values in US$, so that they can be comparable. To do so, BP (2011) prices data for the same years are used.

Another problem in this conversion is that, the gas prices are always calculated as US$ per million Btu, with the latter standing for British thermal units. This is because gas is not generally sold per unit of volume, but rather per unit of energy that can be produced by burning the gas. Therefore, the bcm volumes need to be converted into Btu, and afterwards calculate the resulting Btu price.

To do so we rely on (NATGAS, 2012) online converter, however, the converter is again based on the American system, hence volumes should be only in cubic feet, and therefore, we converted our volumes from bcm to bcf using the following equation: 1 cubic foot = 1,027 Btu (Hofstrand,2007). The detailed calculations are shown in Table

Table 3: The conversion of volume gas to value equivalent (2007 - 2010)

	2007	2008	2009	2010	Conversion factor
Billion cubic meters	55.69	58.97	62.69	61.33	
Billion cubic feet	1966.67	2082.51	2213.88	2165.85	*35.314667[12]
Billion Btu	2019774.0	2138733.6	2273651.1	2224326.4	*1027
	Based on US Henry Hub prices				
Price: US $ per million Btu	6.95	8.85	3.89	4.39	
Price: US $ per billion Btu	6950.00	8849.17	3893.33	4388.85	/1000
Price: US $ per Btu	0.000007	0.000009	0.000004	0.000004	/1000000000
value US$ billion	14.04	18.93	8.85	9.76	
value US$ million	14037.43	18926.01	8852.08	9762.23	/1000
	Based on average prices[13]				
Price: US $ per million Btu	6.79	9.80	5.16	5.66	
Price: US $ per Btu	0.000007	0.000010	0.000005	0.000006	
value US$ billion	13.71	20.96	11.74	12.59	
value US$ million	13708.71	20955.86	11736.99	12591.47	

[12] Conversion factor: 1 cubic meter = 35.314667 cubic feet

[13] This average is alculated considering: (1) European Union cif, (2)UK Heren NBP Index, (3) US Henry Hub, and (4) Canada (Alberta).

Appendix 3: Detailed impacts of Scenario2 on Egypt's GDP

	GDP from the expenditure side					
	Base Scenario2	Updated Scenario2	Change	% change	Share Base	Share updated
Consumption	95705.91	97007.70	1301.79	1.36%	75.27%	75.32%
Investment	27015.44	27284.60	269.164	1.00%	21.25%	21.18%
Government	14974.75	15188.70	213.952	1.43%	11.78%	11.79%
Exports	38716.73	38818.90	102.166	0.26%	30.45%	30.14%
Imports	-49255.65	-49502.30	-246.65	0.50%	-38.74%	-38.43%
Total	127157.18	128797.60	1640.42	1.29%	100.00%	100.00%

	GDP from the sources side					
	Base Scenario2	Updated Scenario2	Change	% change	Share Base	Share updated
Net factor income	103771.2	104489.9	718.7	0.69%	81.61%	81.13%
Net taxes	11182.69	12040.9	858.21	7.67%	8.79%	9.35%
Depreciation	12203.28	12266.9	63.62	0.52%	9.60%	9.52%
Total	127157.2	128797.7	1640.5	1.29%	100.00%	100.00%