نموذج كلي محوسب للطاقة المتجددة في فلسطين

A Computable General Equilibrium Model of Renewable Energy in Palestine

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Committee

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“This thesis was submitted in partial fulfillment of the requirements for the master’s degree in Economics from the faculty of graduate studies at Birzeit University, Palestine”.

16/12/2014

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Dedication

To the one with the most compassionate heart and beautiful spirit

my beloved mom

To him who made my way and narrated it with the sweat of his forehead

my dear dad

To them who I grew up between , and shared my life with its sweetness and bitterness
my family

To those who I passed all my hardships with

my dear friends

To those who I am moving with to the world of figures

my colleagues

To those who lightened my way with their knowledge

my distinguished teachers

To the professor who was like a father to me ….Dr yousef Daud

To the soul of Dr Bassim Makhol

Acknowledgment

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Abstract

This thesis finds the economic impact of using solar energy to generate electricity instead of fossil fuels (oil, natural gas and coal) - traditional technique- in Palestine. The thesis especially emphasizes the impact on public finance, external trade, labor market, and households' total income. It is important to study the impact on the public finance because of the accumulated debt to the Israeli Electricity Company which has exceeded NIS 1 billion in 2013. These amounts are usually deducted from the customs clearance. The study also finds the impact on foreign trade, especially trade with Israel because of the dependency of the Palestinian economy on the Israeli economy. In fact, electricity imports forms 10% from total imports from Israel.

The Palestinian economy is characterized by being a 'service economy'. The service sector[1] contributes for the largest share in GDP, which amounts to 75.1% including the electric service. This means that the contribution of the productive sectors such as the agricultural and industrial sectors in GDP is smaller which reflects the fragility of the Palestinian economy. Improving the electricity sector, as part of the service sector, is very necessary for the development of the Palestinian economy in general and the development of the productive sectors, agricultural and industrial in particular.

This study fills the literature gap on energy and the economy in Palestine by analyzing economic effects of solar energy use by using a computable general equilibrium (CGE) model. In addition, it quantifies these effects. Such quantitative analyses have not been done before for the Palestinian economy. Being the first to investigate this important issue, it provides the basis for a more elaborated model that directly addresses renewable energy production for policy recommendations. This study is important to attract the attention of politicians and stakeholders due to its importance in improving the difficult economic situation in Palestine. This study

[1]There are four main sectors in Palestine, agriculture, industry, constructions and services sector (PCBS, 2014). What service sector includes is fully detailed in chapter 1.

utilizes the PalMod CGE model (USAID, 2013) which is based on the Palestinian Social Accounting Matrix for the year 2011. This analysis is carried out using the General Algebraic Modeling System (GAMS) computer package. The data required for the SAM is available from the Palestinian Central Bureau of Statistics (PCBS).

The impact is measured under two different approaches. The first approach assumes no changes in the model and SAM, and assumes changes in the electricity sector according to three scenarios. Scenario1 assumes an increase of total factor productivity in the electric sector by 10% which reflects solar energy technology. Scenario2 assumes an increase of excise tax on electricity imports by 10%. Scenario3 assumes an increase of both total factor productivity as an indicator of increase in domestic electricity production, and excise taxes as a government intervention to decrease the level of imports. The Second Approach alters the model and SAM and adds a new sector after which two scenarios are conducted. Scenario1 alters the SAM only by adding “solar energy sector” with initial values reflecting the current situation, and then assumes an increase of domestic production for this sector. Scenario2 alters model’s equations such that electricity imports from Israel are determined residually (imports are the difference between domestic demand and supply), and then assumes an increase of domestic production of the new sector by 10% and 200%.

The results show that solar energy has a positive impact on government budget, external trade, labor market and households. As for the first approach, under the scenario1, budget deficit will decrease by 0.09%, electricity imports from Israel will increase by 0.76%, labor demand will increase by 1.18%. Finally, households’ total income will increase by 0.36%. Under the scenario2, budget deficit will decrease by 0.23%, electricity imports from Israel will decrease by 6.07%, labor demand will decrease by 10.17% and households’ total income will decrease by 0.74%. Under the scenario3, budget deficit will decrease by 0.138%, electricity imports from Israel will decrease by 5.37%, labor demand will decrease by 9.13% and households’ total

income will decrease by 0.4%. As for the second approach, under the scenario1 when assuming that the value of production from solar energy sector is $0.2 million followed by a 10% increase in production, in general there were positive but small effect on public finance, external trade, labor market and households' income. Under the scenario2 an increase of domestic production by 200% will lead to a decrease in budget deficit by 0.0008%, decrease in electricity imports from Israel by 0.467%, decrease in unemployment level by 1.107% and increase in households' total income by 0.505%.

Key words: solar energy, CGE, SAM.

ملخص تنفيذي

تهدف هذه الرسالة إلى دراسة أثر استخدام مصادر الطاقة المتجددة، خاصة الطاقة الشمسية البديلة عن المصادر التقليدية مثل الوقود الأحفوري (الغاز الطبيعي، الفحم الحجري، ...)، لإنتاج الطاقة الكهربائية على الاقتصاد الفلسطيني. وبصورة خاصة، تركز الدراسة على الأثر المتوقع على كل من موازنة السلطة الفلسطينية، والتجارة الخارجية، والقوة العاملة. تعود دراسة الأثر على موازنة السلطة بشكل أساسي بسبب عبء الديون الكبير المتراكم عليها لصالح شركة الكهرباء الإسرائيلية والبالغ 1 مليار شيقل إسرائيلي في العام 2013 والذي يتم اقتطاعه من المقاصة. أما دراسة الأثر أيضاً على التجارة الخارجية خاصة التجارة مع إسرائيل ، فيعود إلى تبعية الاقتصاد الفلسطيني للاقتصاد الإسرائيلي المتزايدة خاصة في الاستيراد، حيث تشكل نسبة الواردات من الكهرباء ما قيمته 10% من إجمالي الواردات مع إسرائيل.

يعتبر الاقتصاد الفلسطيني اقتصاد خدماتي في الأساس، حيث تشكل نسبة مساهمة الخدمات الحصة الأكبر في الناتج المحلي الإجمالي والتي تبلغ 75.1% باعتبار الكهرباء جزء من الخدمات. وهذا يعني أن نسبة مساهمة القطاعات الإنتاجية مثل القطاع الزراعي والصناعي في الناتج المحلي الإجمالي قليلة جداً مما يعكس هشاشة بنية الاقتصاد الفلسطيني. إن تحسين قطاع الكهرباء، باعتباره جزءاً من القطاع ألخدماتي، ضروري جداً لتنمية الاقتصاد الفلسطيني بصورة عامة، وتنمية القطاعات الإنتاجية بصورة خاصة.تشكل هذه الدراسة إضافة لموضوع الطاقة والاقتصاد في فلسطين من خلال تحليل الآثار الاقتصادية لاستخدام الطاقة الشمسية باستخدام نموذج توازن كلي محسوب (CGE). بالإضافة إلى ذلك، إن مثل هذه الدراسة والتحليل الكمي لموضوع الطاقة الشمسية لم يسبق تطبيقه من قبل على الاقتصاد الفلسطيني. وتعتبر هذه الدراسة مهمة لجذب انتباه أصحاب المصالح نظراً لأهميتها في تحسين الحالة الاقتصادية الصعبة في فلسطين. وتعتمد الدراسة على نموذج PalMod CGE الذي يستخدم في الأساس المصفوفة الحسابية الاجتماعيةSAM لفلسطين لعام 2011.

لتحليل الآثار المذكورة، بنيت الدراسة على نهجين مختلفين. النهج الأول يفرض عدم وجود أي تغييرات على المصفوفة الحسابية الاجتماعية والنموذج. يحتوي هذا النهج على ثلاثة سيناريوهات مختلفة. يفترض السيناريو الأول زيادة في إنتاجية قطاع الكهرباء بنسبة 10%، وتعكس هذه الزيادة التقدم التكنولوجي المتمثل في استخدام الطاقة الشمسية. ويفترض السيناريو الثاني زيادة الضريبة على واردات الكهرباء بنسبة 10%. أما السيناريو الثالث، فيفترض زيادة في كل من إنتاجية قطاع الكهرباء وفي قيمة الضريبة على واردات الكهرباء كتدخل للحكومة بنسبة 10% . أما النهج الثاني، فيفرض وجود تغييرات على المصفوفة الاجتماعية والنموذج بناء على سيناريوهين. يفترض السيناريو الأول تعديل المصفوفة الاجتماعية من خلال إضافة قطاع آخر سمي بقطاع الطاقة البديلة (الشمسية) يشمل بيانات تعكس الوضع الحالي متبوع بزيادة بنسبة 10% للإنتاج المحلي من هذا القطاع. ويفترض السيناريو الثاني وجود تغيرات على معادلات النموذج، بحيث تحدد واردات الكهرباء من

إسرائيل على أنها حاصل الفرق بين الطلب والعرض المحلي على الكهرباء، ومن ثم زيادة في الإنتاج المحلي بنسبة 10% و200%.

تشير نتائج النهج الأول إلى أن استخدام الطاقة الشمسية في فلسطين كبديل عن المصادر التقليدية له أثر إيجابي عل كل من القطاع الحكومي، والتجارة الخارجية مع إسرائيل، وسوق العمل ودخل الأفراد. في السيناريو الأول، يقل العجز في موازنة الحكومة بنسبة 0.09%، وواردات الكهرباء من إسرائيل ستزيد بنسبة 0.76%، في حين أن الطلب على العمالة سيزداد بنسبة 1.18%، بينما الدخل الكلي للأفراد سيزداد بنسبة 0.36%. أما في السيناريو الثاني، فتشير النتائج إلى أن العجز في الموازنة سيقل بنسبة 0.23%، وواردات الكهرباء من إسرائيل ستقل بنسبة 6.07%، والطلب على العمالة سيقل بنسبة 10.17%، والدخل الكلي للأفراد سيقل بنسبة 0.74%. وفي السيناريو الثالث، تشير النتائج إلى أن عجز الموازنة سيقل بنسبة 0.138%، وواردات الكهرباء من إسرائيل ستقل بنسبة 5.37%، والطلب على العمالة سيقل بنسبة 9.13%، والدخل الكلي للأفراد سيقل بنسبة 0.4%. أما بالنسبة للسيناريو الأول من النهج الثاني، عند فرض أن قيمة الإنتاج المحلي للكهرباء من قطاع الطاقة البديلة يساوي 0.2$ مليون متبوع بزيادة بنسبة 10%، تشير النتائج إلى وجود أثر إيجابي بشكل عام، لكنه صغير جدا، على الميزانية العامة، التجارة الخارجية، سوق العمل ودخل الأفراد. أما بالنسبة للسيناريو الثاني، زيادة الإنتاج المحلي بنسبة 200% يؤدي إلى انخفاض عجز الميزانية بنسبة 0.008%، انخفاض واردات الكهرباء من إسرائيل بنسبة 0.456%، انخفاض معدل البطالة بنسبة 1.107% وارتفاع الدخل الكلي للأفراد بنسبة 0.505%.

Abbreviations

C-D: Cobb-Douglas

CES: Constant Elasticity of Substitution

CET: Constant Elasticity of Transformation

CGE: Computable General Equilibrium

EC: Electricity Companies

GAMS; General Algebraic Modeling System

GDP: Gross Domestic Product

GNI: Gross National Income

IEC: Israeli Electric Company

IMF: International Monetary Fund

IO: Input- Output Table

JDECO: Jerusalem District Electricity Company

Kwh: Kilowatt Hour

Kwp: Kilowatt Peak

MNE: Ministry of National Economy

MoF: Ministry of Finance

NIS: New Israeli Shekel

PA: Palestinian Authority

PCBS: Palestinian Central Bureau of Statistics

PEA: Palestinian Energy Authority

PV: Photo- Voltaic

RE: Renewable Energy

ROW: Rest of the World

SAM: Social Accounting Matrix

TFP: Total Factor Productivity

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Chapter 1: Introduction

1.1 Preface

Economic, social and political reasons necessitate a concerted effort to switch to renewable energy in Palestine. As a land locked economy, Palestine depends on Israel for electricity, water, and many more imports which are needed for daily survival. Israel often uses its ability to block or suspend those services as a means of pressure on the Palestinians for political gains. In the past, Israel had restricted access of Palestinian workers from reaching the Israel labor market and had in the past decade resorted to replacing them with foreign guest workers. They have also resorted to blocking fuel supply for the power station in Gaza and sometimes the West Bank either for political reasons or the inability of Palestinians to pay their bills (Abu-Kamish, 2014). These policies have severe repercussions for the Palestinian population. The idea of generating electricity from renewable resources should have been pursued by the Palestinians (by the government or private sector) long ago as a means of reducing dependence on Israel. This has materialized recently (2012) when a new law was passed allowing for households to integrate home produced energy from renewable sources to be fed into to the network (pwc, 2012).

1.2 Problem Statement

Because of the aforementioned reasons, this study aims to analyze the effects of switching to renewable energy in Palestine on different aspects of the economy. Switching to renewable energy is applicable and has proved its efficiency in many countries in the world. Will it be applicable in Palestine? If it is applicable, then:

- What effects would it have in the economy?.
- Who would benefit from implementing it and who would lose?.
- In the light of government deficit, would a renewable energy program in Palestine deepen the deficit, increase it or will it have no effect?.

- Would it reduce Palestinian dependency to Israel through reducing electricity imports from Israel?.
- What would be the impact on other sectors of the economy?.

1.3 Objectives of the Study

The study aims to achieve the following main objective: Describe the status-quo and build a base of renewable energy in Palestine for households, private sector, and Palestinian government and policy makers. This is done by addressing the following:

- Measuring the impact of implementing a renewable energy program in the Palestinian economy especially on public finance, external trade, labor market and households income.
- Simulate an existing model to mimic renewable energy (RE) sector in Palestine.
- Adjust the model to include a new sector and simulate the new model to show the effect of an increase in RE production in Palestine.

1.4 Importance of the Study

The replacement of fossil fuels as a generator of electricity with renewable energy sources such as wind, water, and solar energy is not only beneficial to households, but also to the environment. One of the reasons for the shift to renewable energy is to reduce carbon dioxide (CO_2) emissions resulting from the combustion of fossil fuels within the traditional electricity generators, which pollutes air and causes global warming. Meanwhile, renewable energy sources are cleaner and do not badly affect air quality. Sustainability and environmental friendliness are the driving forces behind supplementing dark energy with green energy.

Although analyzing the environmental impact is very important, we are not prepared to deal with this issue at this conjuncture for many reasons; the most important of which time and data constraints. This thesis will provide insights into the delayed Palestinian adoption of the renewable energy strategy. The study analyzes the interests of different stakeholders starting with households, the Palestinian electricity suppliers and most importantly the Palestinian Energy Authority (PEA). The model's simulations will analyze the effects of using solar energy in the Palestinian economy through shocking the tariff rate on electric imports (which simulates lower electric imports supposedly due to increased domestic production of renewable energy), and the technical improvement of electric generation (to simulate increased domestic production of electricity) on public finance (net lending), external trade with Israel as electricity constitutes a large share from total imports, household savings, and on the labor market.

1.5 Methodology of the Study

This study quantifies the impact of using renewable sources as generator of electricity on public finance, trade, labor market and households' income. The study uses the computable general equilibrium technique CGE and the GAMS software to obtain results. In our study CGE model depends on the Palestinian social accounting matrix SAM 2011.This fills the literature gap on energy and the Palestinian economy.

1.6 Limitations of the Study

Main limitations of our study are about the model and data available.

1. The Data obtained from PCBS 2011 SAM is not the most recent data.
2. One of the most important effects of using RE is its environmental impact, at this stage with the constructed model this effect could not be measured. Other studies in the future might improve the model to tack into account the environment as an individual sector or institution and measures this impact.
3. As will be shown in the next chapters, the Palestinian renewable energy initiative is special for households. This means that electricity from renewable sources is produced by households, which needs to change households utility function to capture this change. At this stage firms are assumed to be the

producers of electricity from renewable sources which will give an indicator of the expected effect.

4. The model we deal with is a static model not dynamic. A static model measures effects on an economy at given time (specific year for example) while dynamic model measures the effect over time (couple years for example).

1.7 Contents of the Study

This study is organized as follows: chapter 2 presents the theoretical framework; which will contain a full description of methodology used, empirical review about CGE modeling, description of social accounting matrix (SAM) and ends with data used. Chapter 3 reviews the literature on some countries' experiences in the use of renewable energy sources. Chapter 4 is about Palestinian economy, electricity sector, renewable energy in Palestine and Palestinian SAM. Chapter 5 shows model specification which is a description of the PalMod model which was built specially for Palestine. A presentation of different scenarios, analysis and results are discussed in chapter 6. Chapter 7 concludes and gives policy recommendations.

Chapter 2: Theoretical Framework

2.1 An Overview of CGE Modeling

The CGE modeling is a technique often utilized in situations which require policy simulations which require little data. A CGE model is a set of simultaneous nonlinear (or linear) equations, it is a square model such that the number of equations equal to the number of variables (Lofgren, 2002). The model reflects all transactions that take place between economic agents which are represented in a SAM, i.e. CGE model translates a SAM into equations.

It is general because it takes into account all markets and flows in an economy, it includes households, firms, government, the rest of the world and investment. It is in equilibrium since it assumes equality between demand and supply in all markets. And it is computable as it uses computer software to generate numeric solution of the model (Tuerch et al., 2009).

CGE modeling is widely used in analyzing countries' economies in different fields. For example, it has been used to capture the impact of public investments in irrigation and training for Ethiopian agricultural sector (Mitik, 2013)[2]. It also was used to study how trade openness in Uruguay had improved women's situation in terms of employment and wages (Terra et al., 2008). Another study used CGE modeling to measure the impact of an increase in transfers from Moroccans working abroad in the Moroccan economy (Abdelkhaleq and Dufour, 1998). Waters et al. (1997) used a CGE model to study the impact of property tax limitation on total output and income in Oregon State. CGE analysis was also used to quantify environmental impact of thirteen types of emissions on trade and growth in six countries in Latin America and Asia (Beghin et al., 1996). A general equilibrium multimarket approach was used to

[2] In his CGE analysis, Mitik used a 'top-bottom' approach. A 'top-bottom' approach breaks down a system into subsystems to look inside each of them separately.

study the impact of liberalization of trade on poor cereal importers in low income countries in Asia and Africa (Sadoulet and Janvry, 1992).

In Israel, a CGE model based on Israeli SAM of 1995 was used to find the impact of an ad-volerm tax on carbon emissions on the Israeli economy and environment to achieve the environmental goal of 20% decrease in carbon emissions by 2020. The authors found economic effect under different values (scenarios) of carbon tax, a tax of NIS 50 per ton, NIS 100, NIS 150 and NIS 200. In general, implementing such a tax will cause electricity prices to increase by 5% to 17% under different scenarios, coal prices will increase by 25% to 100%. This will lead to a decrease in coal use, as a generator of electricity, by 10-40%, and electricity itself by 10-27%, while the environmental impact is presented in the reduction of carbon emissions by 9-25% (Paltink & Shechter, 2010). This might be an indicator to start using renewable sources in generating electricity, or it might be an indicator of the need of implementing a tax on carbon emissions in order for shifting to use renewable instead of traditional sources to be effective and have significant positive effect, environmentally and economically.

Missaglia and Boer (2002) used CGE modeling to study the effect of emergency assistance policies concerning food, cash and employment in Palestine. The model was calibrated on a modified 1998 SAM; they used 1998 SAM and modified it according to what they called ‘intifada shock. Those changes such as change in labor income, reduction in government savings, increase in labor force…etc. This modified SAM became their base to analyze the shock of emergency assistance policy. They found that under food aid program gross national income (GNI) will increase by 5% and government revenues will decrease by 9.5%. While under monetary aid program GNI will increase by 12% and revenues will not change. So they concluded that for Palestinians under occupation, monetary foreign aid (cash) is better than food foreign aid. Since, in addition to GNI difference under both scenarios, under food aid program Palestinians households will replace domestic commodities with cheaper imported ones.

In their model, there are five economic agents; eight firms, one household, one bank, the government (PA) and the rest of the world. Each firm makes it decision according to a constant elasticity of substitution function and allocates value added between labor and capital. Household maximize their utility function and allocates income between leisure and labor at the first stage. At the second stage, income is allocated between different commodities. The government maximizes a Cobb-Douglas utility function to allocate revenues between public and private services. Revenues include taxes and foreign aid. The bank accepts savings from the household, the government and foreign savings. And then allocate these saving between investment demand for commodities according to a Cobb-Douglas function.

Another study by Boer and Missaglia (2006) analyzed a model that was more theoretical than analytical, they mainly aimed to find the difference between two different models that are used to estimate Engel curve[3]. The two models are: an Indirect Addilog System (IAS)[4], which assumes non-linear Engel relation, and a linear expenditure system (LES), which assumes a linear Engel relation. Both models estimated income elasticity of commodities using 1998 Palestinian Expenditure and Consumption Survey (PECS), and then they modified 1998 SAM by replacing old income elasticities (obtained from LES model) with new estimated elasticities (obtained from IAS). After that they use Palestinian CGE model to find the impact of 'intifada' shock on commodities expenditure under four different scenarios according to four different values of Frisch parameters[5] for both LES and IAS Engel relations. The main result was that under LES model an increase in prices is lower and

[3] Engel curve shows relation between expenditure on a specific good (either absolute expenditure or shares of income) and total expenditure.
[4] IAS allows for non-linear Engel relation i.e. variable budget shares, inferior goods and elastic demand.
[5] Frisch parameter is expenditure elasticity of the marginal utility of expenditure.

reduction in expenditure for all commodities is greater than IAS model. As mentioned above, the study is more theoretical. It aimed to show that under IAS model which is more general than LES, results differ. This difference might mean that LES overestimates the results since it is a special not general case.

In general CGE models are used to capture the effect of a shock, policy changes or changes in one of exogenous factors, and shows how an economy react to such changes.

To find the impact of using solar thermal energy in Palestine and policy implication this study will utilize PalMod CGE model which is calibrated on the Palestinian SAM of 2011 using general algebraic modeling system GAMS software.

2.2 Social Accounting Matrix

2.2.1 Introduction

The social accounting matrix ‘SAM’ is a representation of all transactions between all parties in a nation’s economy at a given period of time, usually a certain year. SAM is a square matrix; each row presents a receipt (incoming), while each column presents an expenditure (outgoing) of a given sector. And each cell in the matrix presents the value of transactions or payment from column account to row account with equal totals of rows and columns, i.e. total revenues equal total expenditures. It is called social because it doesn’t provide only economic data, it also provides social data. SAM main two functions are: (1) to describe countries’ economies through presentation of socio-economic data at a given period of time, it provides information on consumption, production, income, import, export, employment,….etc. (2) it is the base for analyzing an economy, especially political analysis, using mathematical techniques such as CGE model. A basic structure of a SAM contains the following accounts: the activities or production account, the commodities account, the factors of production account: labor and capital, the institutional account: households, firms, government and rest of the world 'ROW', capital account and total of all accounts. Those accounts are same for any economy, but each account is divided into sub accounts which differ across countries or regions. In general accounts will be divided according to the purpose of the study. This study will use Palestinian SAM in order to illustrate how a SAM is used to describe economic behavior of a country.

2.2.2 SAM Features

Any SAM has many features. According to Lofgren and Harris (2002) the following are main features of a SAM:

1. SAM distinguishes between activities account and commodities account. Activity accounts reflect the supply or production side of an economy, and commodity accounts reflect the demand or consumption side.
2. Activities may produce different commodities. Similarly, any commodity could be produced by different activities.
3. SAM takes into account the transaction costs resulted from trade. Transaction costs are calculated in commodities' values.

In general a SAM might be in macro or micro structure. The macro structured SAM provides data about all accounts in aggregate values. While the micro structured SAM is the disaggregation of the macro SAM, it disaggregates all accounts into sub accounts, so it is more detailed. Full details about SAM is described using the Palestinian 2011 SAM in chapter 4.

2.3 SAM Versus Input Output Matrix[6]

Both SAM and input output 'IO' matrix are used for analyzing an economy. The difference is in what each matrix contains. IO matrix can be considered as a sub matrix of SAM. IO matrix is a symmetric matrix that presents the flow of goods and

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[6] For more information about the differences between a SAM and input output tables and how they differ in analyzing a country's economy a good example of Ethiopian economy might be useful on the following link: http://www.edri-eth.org/Documents/SAM%20document%20with%20list%20of%20tables.pdf

services among sectors. IO shows distribution of inputs (intermediate inputs from other industries) and outputs (for final consumption) among different institutions. In simple words, each row of an IO matrix shows the distribution of output produced by industry presented in that row and how it is used as input in other industries. The distribution of outputs is either intermediate inputs for other industries or output for final consumption by households, while SAM is an extension of IO matrix. In addition to the transactions that take place in the production side, SAM takes into account all other transactions in the economy including investments, savings, and income distribution ….etc. between all institutions including ROW. Table 1 shows an input-output table, each row presents the final output for $industry_i$ that is used as intermediate input in $industry\ _j$ presented in columns. $I_{i,j}$ is the intermediate inputs from industry j used in industry i.

Table 1:: Input-Output Table

Input / Output	$Industry_1$	$Industry_2$	……………	$Industry_n$
$Industry_1$	$I_{1,1}$	$I_{2,1}$		$I_{n,1}$
. .				
$Industry_n$	$I_{1,n}$	$I_{2,n}$		$I_{n,n}$

2.4 Data Collection

The required data for this thesis are presented in the 2011 Palestinian SAM shown in Table 5 in chapter 4. These data are collected from the Palestinian Central Bureau of Statistics, Ministry of Finance, Ministry of National Economy and the International Monetary Fund. These data are about supply, national accounts, data on the labor force, data on the capital stock, data on investments, data on the different branches of activities and commodities, data on public finance, data on subsides, taxes, transfers and social contribution, and foreign trade data. The most recent data available is for the year 2011.

2.5 General CGE Model Description

2.5.1 Introduction

Representing an economy as a whole system was first established by Leon Walras in 1954 at which general equilibrium model was formulated (Vivian, 1992). After that, economists have developed Walras's work and they constructed computable general equilibrium models which have been used in policy analysis and forecasting (Dinwiddy and Teal, 1988).

General equilibrium takes into account inter-relationship between different markets in the economy. It is build upon what's called 'Walras law'. Walras law states that for a given set of prices, if all goods in all markets are desirable, then the sum of excess demand in all markets is zero, i.e. demand equals supply in all markets, i.e. if $n-1$ markets are in equilibrium then the n^{th} market is in equilibrium also(Vivian, 1992).

2.5.2 Use of CGE Model

CGE model shows how a model is calibrated using SAM data in a given year at which the existing equilibrium is called 'benchmark equilibrium'. Then it shows how an economy reacts to any distortion. The effect on economic behavior is quantified by comparing new equilibrium values with the benchmark. Distortions like change in taxes, policy changes, or any change in any exogenous factor affecting the economy. In general, if tax rate is increased or decreased, then theoretically one might expect its qualitative impact on economy by analyzing and tracing this impact in all different economic sectors. But when dealing with more complex change or combination of changes then numerical methods are needed and theoretical analysis become insufficient in making policy options.

2.5.3 Conditions of CGE Model

To solve for equilibrium, CGE models assumes the existence of market clearance, zero profit and income balance (Wing, 2004).

- Market clearance means demand equals supply in all markets.
- Zero profit means that no sector earns positive profit.
- Income balance means income equals expenditure and households satisfy their income constrains.

2.5.4 Characteristics of CGE model

Here are some of the features of CGE:

1. In CGE models absolute prices for each good can't be determined. Instead, relative prices can be known with respect to one of goods price which is called 'numeraire'. The price of the numeraire is taken to be fixed or equals 1, and all other prices are calculated with relative to it, i.e. prices are interpreted in terms of the numeraire. This because all variables values are calculated from the SAM which measures the value of transactions. So when we need to compare two commodities for example then prices are needed, one price (numeraire) is fixed to compare other prices with it. In other words the number of variables will be greater than the number of equations.

2. A CGE model assumes the existence of three balances: government balance, external balance and saving-investment balance (Lofgren and Harris, 2002)[7].
3. CGE model is designed such that it helps in determining a country's economic features.

2.5.5 General CGE Model

A CGE model describes transactions between economic agents in equations. The following is a brief overview of a general CGE model. This section shows how a SAM is translated into a model, or how a model is built on the SAM. Full details in equation are shown in the next chapter.

1. Households

Households represent the demand side of the economy. Households are assumed to maximize their utility function, which is a function of all commodities domestically produced and imported, subject to their budget constraints to obtain the level of composite demand and the level of savings. Households' preferences[8] may have different forms such as Cobb-Douglas C-D which was used by Cansino et.al. (2011). Paltink and Shechter (2010) and Terra Bucheli and Estrades (2008), or Constant Elasticity of Substitution CES function which was used by Missaglia and Boer (2004) and Mitik and Engida (2013). At the first stage households determine the level of commodities to be consumed according to a C-D or CES function. At the second stage, they choose to allocate consumption between domestic and imported

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[7] A CGE model requires government balance which means that all government revenues (taxes, transfers, etc) equal its spending and savings. External balance or balance of payment equilibrium which means that the difference between trade and capital flows is zero, or countries foreign exchanges are zero (earnings equals spending) . And savings-investments balance means that total savings (household, business, government and ROW savings) equal investments (fixed investment and change in inventory).

[8] Results depend on which functional form we use since elasticities differ and so results will differ i.e. the value of change.

production according to Armington function[9]. They minimize their cost function subject to composite demand function.

2. Firms

Each representative producer either maximize profit function or minimize cost function given production technology, in order to determine the level of output, intermediate inputs and factors of production (capital-labor mixes) that would be used in the production process. At the first stage a firm chooses the level of intermediate inputs and factors of production level according to e.g. a Leontief production function[10] which was used by Missaglia and Boer (2013). At stage two, the firm decides the level of value added, e.g. according to a CES function which was used by Paltink and Shechter (2010) and Sadoulet and Janvry (1992). And finally at the third stage the firm chooses to allocate the level of production it produced between domestic sales and export according to Armington function.

3. Government

Government function is to collect taxes and receive transfers from different institutions (households, firms, rest of the world) which form government revenues. And it spends them on purchasing commodities for public and private consumption.

4. Rest of the world (foreign trade)

[9] Armington function was first developed by Paul Armington in 1969. It is widely used in studying trade policy, and it assumes imperfect substitution between goods from different regions. Next chapter shows a presentation of Armington function in the Palestinian economy. For more information one can see Lloyd and Zhang (2006).

[10] Leontief production function, which is also called Leontief input-output function, is named for Wassily Leontief, it assumes fixed proportions of inputs in their share of outputs production, and it does not allow for substitutability between inputs. Leontief production general form is: $y = f(x_1, x_2) = \min(ax_1, bx_2)$, where y is output and x_i refers to input.

Rest of the world presents foreign trade. The main assumption is that goods from different regions are not perfect substitutes. It is also based on small country assumption where the country is a price taker in both imports and exports.

For domestic consumers, as mentioned above and in a manner such that they minimizing cost, at the first stage they choose composite level of commodities (domestically produced and imported) which will depend on prices and degree of substitution between them according to CES Armington specification. At the second stage consumers will choose the value of imported commodities across regions according to CES function, it will also depend on prices and degree of substitution between goods from different regions. While domestic producers choose to allocate between supplying their production domestically or abroad at the first stage, and to allocate exportation between different countries at the second stage according to a constant elasticity of transformation CET Armington specification such that they maximize revenues.

5. Prices

CGE model is homogeneous in prices. In most cases prices' equations are linear, which means CGE model is homogeneous of degree zero in prices (Elsenburg, 2003). Only relative prices could be found, and each price is explained in terms of numeraire.

In general, there are different functional forms used in CGE modeling to construct production and consumption functions and trade relations, but the most familiar functions are: Leontief functions, C-D, CES and related function constant elasticity of transformation CET. There might be two important reasons behind using such functions. First, using these functions is slightly easy in numerical analysis. Secondly, they are good enough in describing economic behavior.

2.6 Sensitivity Analysis

CGE models are classified as an approach of sensitivity analysis, also called multiplier analysis. Sensitivity analysis shows how model's outputs react to change in one or more of its inputs (Fasso and Perri, 2002). It can study one change or combination of changes at the same time. Changes such as contribution of an activity in the economy, adding or removing one activity, limit of the constraint e.g. change in income, number of constraints,…..etc. It can be used for several purposes; the most important uses are; to understand the behavior of economy as a whole or the behavior of a specific sector or activity within an economy, and helping policy makers in development decisions (Pannell, 1997).

2.7 General Algebraic Modeling System 'GAMS'[11]

2011 SAM will be translated into CGE model and equilibrium will be solved using GAMS software. GAMS is a programming software that makes solving complicated mathematical model easier. It translates CGE model equations into computer programming which facilitates solving for equilibrium and applies distortion for a given model. It can perform scenarios and analyzing economic behavior through representing it by tables and figures.

[11] More information about GAMS is available at: www.gams.com

Chapter 3: Literature Review

The effect of using renewable energy sources on the different sectors of the economy and the environment has been studied extensively. However, the literature on the economic impact of renewable energy on the Palestinian economy is non-existent. Different studies used different approaches to analyze the impact of solar energy, as an example of renewable energy source, on the economy. Those approaches such as input-output analysis Lehr et al. (2012) and Durrschmidt and Van Mark (2006) and dynamic CGE modeling Calazadilla et al. (2014) and Tuerck et al. (2009). This study will use the CGE model to find the effects of the new application of solar energy on the Palestinian economy, especially trade, public finance, labor market and households total income.

In general, the effects of using solar energy instead of fossil fuels are: First, solar energy is a clean and safe source so it does not contribute to air pollution. Second, it provides significant job opportunities during its construction, installation, operation and maintenance. And finally, it reduces the dependency on fuel imports (Tsoutsos et al., 2005).

Cansino et al. (2011) studied the effect of solar thermal electricity technology on Andalusia productive activities[12] using the CGE modeling. They found that according to the Sustainable Energy Plan for Andalusia (PASENER), which aims to increase energy production from renewable resources from $11MW$ in 2007 to $800MW$ in 2013, and under two different scenarios, there will be a remarkable increase in production of different activities. This increase resulted from operating, and maintenance of, solar energy plant. The two different scenarios or technologies are, the solar tower power plant, and the solar collector power plant. The level of productive activities would be increased by 30% under the solar collector power plant

[12] They want to find change in production of different activities, which are 27 in there model, resulted from investment in solar energy.

technology, and by 5% for 30 years under the solar tower power plant technology. Given that under both scenarios the large increase is in transport and communication activities which can be explained by increase in construction and operation of new plants which leads to increase in demand of transport and communication services

A recent study by Calazadilla et al. (2014) measuring the economic effect of “Desert Power 2050” project, which aims to produce electricity from desert regions in the Middle East and North Africa (MENA) utilizing solar and wind energy, and export to Europe (EU), using multi-sectoral, multi-regional dynamic CGE model, and focusing on 6 MENA countries and 9 European countries. They measured the impact of solar and wind energy production on real income under four scenarios. The first scenario is ‘the self-financing scenario’ where each region, MENA and EU, produce electricity independently from their own renewable source. The second scenario ‘the EUMENA financing scenario’ there will be financial corporation from all regions to support MENA to produce electricity for their own use and to export to Europe. In both scenarios there is no political intervention, while under the third and fourth scenarios they assume intervention to reduce CO_2 emissions. The third scenario ‘decarbonized scenario’ assumes that all regions financially support MENA countries in their electricity production with policy limitations on CO_2 emissions and without electricity trade between MENA and EU. And the fourth scenario ‘the trade scenario’ assumes financial support and allows for trade between regions. The results show that under ‘the self-financing scenario’ there will be decrease in real income in both MENA and EU regions by 5% and 3% respectively. This is because acting independently and with no subsidies or limitations on CO_2 emissions mean higher costs. Under ‘the EUMENA financing scenario’ since there will be financial support and with no electricity trade, EU regions’ real income will decrease, but for MENA regions some will face a decrease in real income but less than the decrease faced under ‘the self-financing scenario’, and other regions will face income gains. So in general under both scenarios there will be income losses in both MENA and EU regions because of non-existence of policy climate which will result to inability to compete with fossil fuels prices. Under 'the decarbonized scenario' real income in MENA will increase up to 2.5%, where real income in EU will decrease but less than decease that will occur under the first two scenarios. Finally, under 'the trade scenario' interconnection between regions will lead real income to increase by 7% in MENA regions. While real income losses in EU will be decreased by 2%. As for effect on employment results show that during investment phase there will be creation of an average of 500,000 jobs, and an additional 160,000 to 380,000 jobs during production phase (Calazadilla et al., 2014).

Silva et al., (2011)used the structural vector autoregressive (SVAR) methodology on a sample of four countries which are: USA, Denmark, Portugal and Spain along the period 1960 t0 2004. This study investigated the effect of an increase in electricity generation from renewable sources[13] on CO_2 emissions and gross domestic product GDP growth. The results show negative relationship between electricity production from renewable sources and CO_2 emissions and GDP growth. This negative relationship was explained by additional cost resulting from using renewables which could be eliminated by political intervention. This will increase degree of competition by making electricity generated from renewable sources cheaper.

In Iran, investing in solar energy systems will yield economic benefits, for each house that installs solar thermal array there will be a net revenue of about $168 per year resulting from decrease in use of electricity generated from traditional sources. And if 25% of population (households) installs solar array, then total revenues will reach $1800 million. This is in addition to its positive effect on environment presented in 503,000 tones reduction of CO_2 (Abbaspour et al., 2005).

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[13] Electricity generation from renewable sources is measured by its ratio from total electricity production.

In Nevada, a study used Regional Economic Model, Inc REMI[14] to study the impact of installing solar thermal plants in Nevada along the time period of 1969 to 1998 under three different scenarios that differ in capacity. Under scenario A, where one solar plant will be constructed producing 100 MW[15], each year there will be a creation of 1400 direct and indirect jobs during construction phase, and about 140 jobs during operation and maintenance phase, there will be an increase in personal income by $ 30 million, and an increase of $ 29 million in Gross State Product GSP[16]. Under scenario B if 10 plants will be constructed producing a total of 1000 MW, then annually about 1800 jobs will be created, personal income will be increased by $200 million, and GSP will increase by $349 million. And finally under scenario C if there will be a construction of plants with capacity that meet 70% of renewable energy production, then there will be an additional 4900 jobs during construction phase, and each year there will be a creation of 475 jobs during operation and maintenance phase, $79.5 million increase in personal income, and $75 million increase in GSP (Schwer and Riddel, 2004).

As for Tunisia, a study used input-output analysis shows that all already existing renewable energy activities created about 3500 permanent jobs during 2005/10 period. And according to Tunisian solar plan, investing about Tunisian Dinar TND 9 billion up to 2030 will create 7000 more jobs opportunities, it will also make GDP to grow by an additional 0.4%, investment by 1.4% and export by 0.1% (Lehr et al., 2012).

In North Carolina, a study measured the impact of constructing electricity facilities that utilize renewable energy sources such as energy from solar, wind and biomass

[14] Regional economic model, Inc REMI is a multi variant, multi equations model which combines four techniques together: input-output modeling, general equilibrium modeling, econometric model and account for economic geographic features. For more information one can visit the following website www.remi.com
[15] MW is megawatt, mega=10^6 watt=10^3 kilowatt.
[16] Gross state product GSP is the same as gross domestic product but at the state level.

and hydroelectric energy. According to the state renewable energy efficiency portfolio standard (REPS) established by North Carolina's senate, 12.5% of electricity consumed must be generated from renewable sources by 2021. The economic impact was measured using a five-year dynamic CGE model along the time period of 2008 to 2021[17] under two different scenarios. The first scenario where consumers will incur costs of establishing renewable energy facilities (cost of construction, maintenance and operation, and capital cost), i.e. cost will be recovered by imposing high prices on customers. While in the second scenario costs will not be recovered i.e. electricity facilities will incur costs and those costs will not be reflected in prices. Under 'recovery scenario' by 2021, about 3600 jobs will be lost; investment will be decreased by $43.2 million, real disposable income by $56.8 million, real GSP by $140.35 million, and state revenues by $43.49 million. Under the second scenario, the negative impact is even larger. By 2021, about 15,000 jobs will be lost, investment, real disposable income, real GSP and state revenues will all be decreased by $182.61 million, $271.15 million, $606.65 million and $246.57 million respectively. This is due to the fact that in both scenarios private electricity facilities will construct renewable system with no government subsidies that cover costs or part of them, this will either cost facilities themselves or customers as increase in prices which will lead to decrease in disposable income, investment and so GSP (Tuerck et al., 2009).

The Beacon Hill Institute (2013) analyzed the effects of using renewable energy in Arizona. The impact on Arizona's economy was measured using a State Tax Analysis Modeling Program 'STAMP' according to Arizona's 2006 act which requires its electricity utilities to produce 15% of electricity using renewable energy by 2025. Results show that by 2025, electricity prices in Arizona will increase by an additional 6% making electricity bill for each household to increase by an additional $128

[17] The five years are 2008, 2012, 2016, 2018 and 2021. REPS assumed 3% of electricity consumed must be generated from renewable sources by 2012, 6% by 2016, 10% by 2018 and 12.5 % by 2021.

annually, which makes electricity cost to increase by $389 million, in addition, 2500 jobs will be lost. Disposable income and investment will be decreased by about $334 million and $38 million respectively.

In Germany, using renewable sources has been started long ago, this existing system created about 230,000 additional jobs by 2006, and decreased expenditure on electricity produced using fossil fuels by 5 Euro billion. Assuming that 30% of total electricity production will be generated using renewable sources by 2020, then results on a sample of 105 individual companies (manufacturing and service companies) show that these companies will face high growth rates, increase internalization of markets, increase in investment volumes and employment (Diekmann, 2008). Another study about Germany made by Federal Ministry for the Environment, Natural conservation and Nuclear Safety in 2006 studied the effect of using renewable energy on labor market. Using input-output analysis and as the previous study assuming 30% of total electricity will be generated using renewable sources, it is expected that by 2020 about 300,000 additional jobs will be created, and earnings for each employee will increase by 36% (Durrschmidt and Van Mark, 2006).

A study about Israel found the effect of using renewable energy to generate 10% of Israeli total energy by 2020 on fossil fuels savings and the need for backup in the Israeli electricity system[18]. This study takes into consideration both Israeli and Palestinian demand and that Israel is an electricity island i.e. it can't import electricity. Using different softwares[19], results show an increase of fuels saving in both fixed and variable costs which is estimated to be between 40.4% and 54.5%. Given that electricity generated from renewable sources is intermittent, the need for backup emerges especially in the night and winter and declines in summer. Backup

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[18] How much electricity from traditional sources is needed due to the fact that renewable sources are interrupted.

[19] Software packages such as Statistical Analysis system (SAS) and Unit Commitment Optimal Dispatch (UCOD), optimizing the problem of minimizing costs or maximizing profits subject to different system constraints.

means the need for electricity from non renewable sources which is not intermittent. Results show that natural gas is the best choice as it is cheaper and less pollutant (Fakhouri, 2013).

Thus far, quantifying the impact in Palestine, as well as, simulating the model for various domestic production quantities on the domestic economy is non-existent. This study will fill the literature gap on energy and the economy in Palestine by analyzing economic effects of solar energy using CGE modeling.

Chapter 4: An Overview of the Palestinian Economy

4.1Palestinian Economy

The Palestinian economy is primarily a service economy. In fact, the service sector contributes to the largest share in the GDP. In 2011, this contribution amounted to 75.1% including the electric service (PCBS, 2014). Services include electric service, wholesale and retail trade, transportation and storage, financial and insurance services, information and communication, accommodation and food services, real estate activities, public administration and defense, education, and health and other services. Whereas the electricity sector alone contributes for 1.4% of GDP. This means that the contribution of the productive sectors such as agriculture and manufacturing are small which weakens the structure of the Palestinian economy. The share of the agricultural sector including fishing amounted to 5.9% in the GDP in 2011. The share of the industrial sector was 11.7%, where the industrial sector includes mining and manufacturing. The construction sector contributes for 7.3% of GDP[20]. Improving the electricity sector, as part of the service sector, is necessary for the development of the Palestinian economy as a whole and the development of the productive agricultural and industrial sectors.

4.2 Electricity in Palestine

Every country must improve its infrastructure to speed the pace of development. Electricity as a component of a country's infrastructure is very important and becomes more important as other sectors in the economy grow during different stages of development. The lack of efficient infrastructure prevents economic progress and growth. The electricity sector in Palestine has been deemed as both inefficient and costly[21]. Despite that, the percent of Palestinian households who are connected to public electricity networks have increased from 97.2% in 1999 to 100% in 2013

[20] This classification is according to the PCBS.

[21] Frequent interruptions of supply especially during winter, the lost energy during transmission, inefficient revenue collection are but a few of these sectors problems. For example, Jerusalem District Electricity Company (JDECO) has suffered net losses for the years 2010 and 2011.

(PCBS, 2014). Like many countries in the world, Palestine suffers from the scarcity of traditional energy sources such as natural gas and fossil fuels, which are used to generate electricity. Those countries have control over their own imports of energy sources; but in Palestine such control does not exist. In Palestine, the only domestic producer of electricity is Gaza electric plant[22] which has very low production capacity, this creates imbalance between domestic supply of electricity and demand. In 2012 it produced only 8.5% of total electricity demanded (PCBS, 2014). The rest is imported from Israel which has the control over the value and the volume of imported energy, it can decide when and how to import, and when to block importation mostly for political considerations. Furthermore, Israel has the control over electricity prices. This badly affects electricity sector in Palestine and the Palestinian economy. This motivates the move towards starting to depend on solar energy to generate electrical power. Solar energy will be used to reduce the Palestinian economy's dependence on the Israeli economy. Electricity imports constitute about 10% of gross imports for Palestine, and about 96% of total electricity imports come from Israel. In general, electricity for the West Bank is supplied from Israel and Jordan. In 2011, the value of electricity imported from Israel was about $343 million, and smaller value of about $9 million was imported from Jordan. Meanwhile electricity for Gaza Strip is supplied from Israel and Egypt. In 2011, the value of electricity imported from Israel and Egypt were $64 million and $9.5 million respectively (PCBS, 2013).

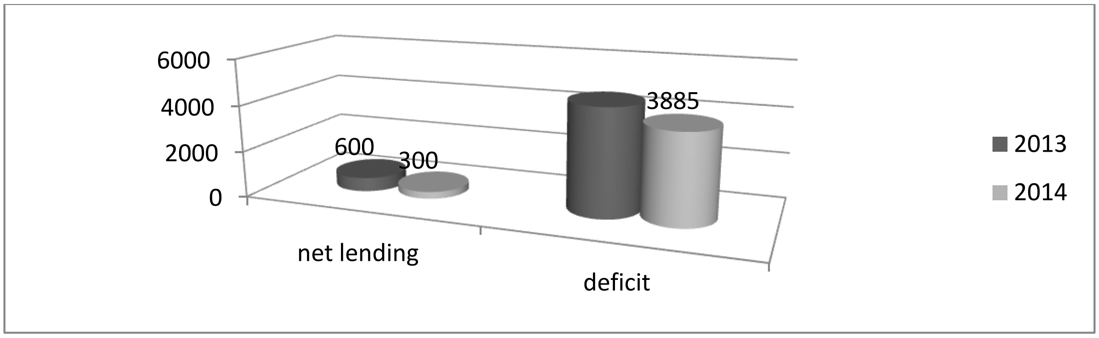
The Israeli Electricity Company (IEC) is the main supplier of electricity to Palestinian electricity companies, this makes electricity sector suffer from a very serious problem which is continuous price hikes due to its control over prices. Thus the PEA and the Palestinian Authority (PA) have to look for a solution, which is the use of renewable, sustainable and clean energy source which has been started but late.

[22] The fuel needed for this plant to operate is totally imported from Israel, which has rendered the plant ineffective during periods in which Israel did not allow the necessary fuel to reach the plant. This was done often due to delayed payments and build up of arrears (Alarab Alyawm, 2014).

Since the other alternative solution presented in an independent Palestinian electrical sector might be elusive, more expensive, and riskier. Moreover, having Palestinian electricity plants will not solve the problem of Palestinian dependency on Israel, nor will price hikes be preventable for as long as Palestinians are bound together with Israel in the quasi customs union which restricts oil prices in Palestine to be similar to those in Israel. Fossil fuels will be imported according to Israeli standards mentioned in Paris protocol. But this doesn't mean complete dependence on the green energy, because green energy is interrupted and the need for black energy still exists. Renewable energy sources are complementary sources to, not replacement for traditional sources. This creates a new serious problem which is the chance for Israel to control prices and increase the price of electricity when backup is needed especially in winter.

Electricity price hikes put PA in big financial difficulties. The debt to IEC has exceeded New Israeli Shekel (NIS) 1 billion (Barakat, 2013). Debt accumulation resulted from the economic hardship facing many Palestinian households who can't pay their electricity bills. As a result, Israel opts to deduct the overdue amounts from customs clearances putting more pressure on PA's current expenditure resulting into government shutdown on many occasions (Barkat, 2013). Figure 1 shows how both net lending and current account deficit increased between 2013 and 2014 from NIS 300 million to NIS 600 million and from NIS 3885 million to NIS 4605 million respectively. Knowing that IEC has deducted NIS 7 billion since 2002, which could have been used to build own Palestinian electricity generation plant or any alternative energy program. If the situation still as it is now, which means if no action will be taken concerning generating electricity in Palestine given the increase of the prices of the imported electricity from Israel, then this might result in great disaster which might be the acquisition of IEC on Palestinian electricity companies or the cut off power supply (Abu-Kamish, 2014).

Figure 1:Net Lending and Current Account Deficit in 2013 and 2014 (NIS million)



Source: Ministry of Finance. (2014). *A summary of public budget draft for the year 2014.*

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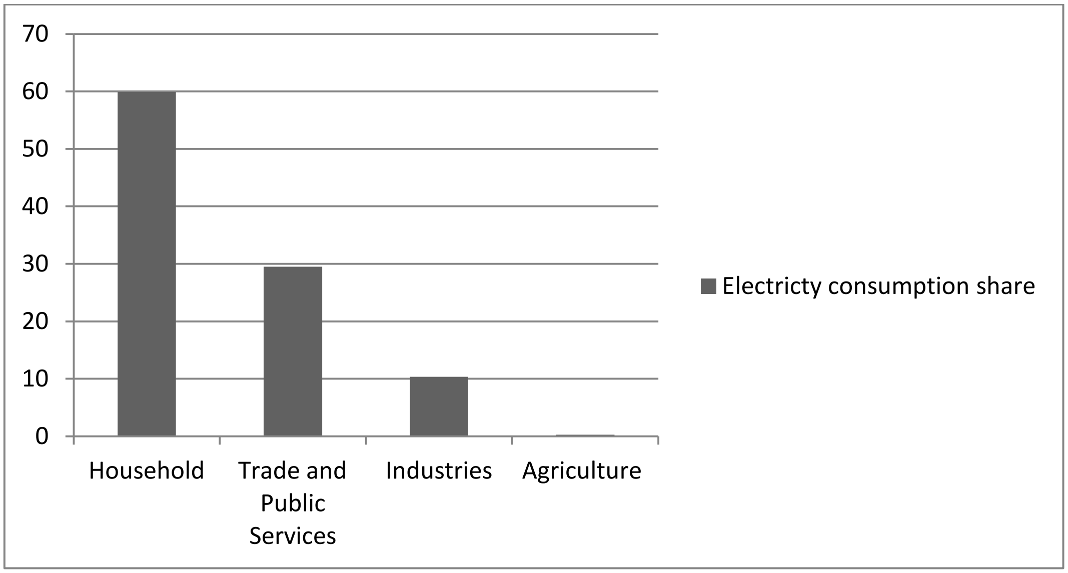
The deficit and net lending situation would be much worse had electric consumption been higher. Figure 2 shows how average electricity consumption is distributed by sectors for the years 2006-2012; 10.36% for households' consumption, 29.5% for trade and public services use, 10.36% for industries and 0.24% for agriculture. Electricity consumption in the agriculture sector is very small because of two main reasons. First, the share of agriculture from total output is less than 5% (it was 4.9% in 2012). And the second reason is the traditional agricultural pattern in Palestine, which depends on simple, primary and home produced tools.

Electricity average consumption per household dropped from 380 kwh[23] per year to 260 kwh per year during the period 1999 and 2013 (PCBS, 2014). Figure 3 shows how electricity consumption has fluctuated during the period of 1999 and 2013 between 200 kwh and 300 kwh. Which is almost the same as Jordan with an average monthly electricity consumption of 225 kwh per household (DOS, 2012).

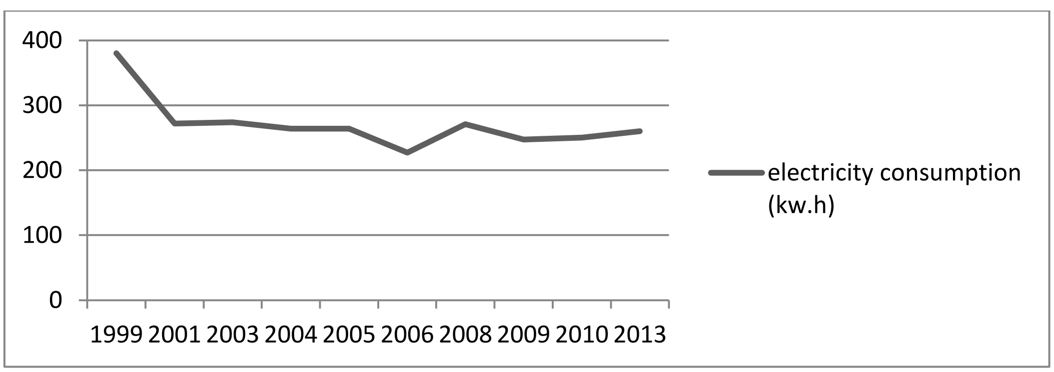
[23] Kwh: Kilowatt hour is a unit of energy.

Figure 2: Electricity Consumption by Different Sectors For the Year 2012 (%)



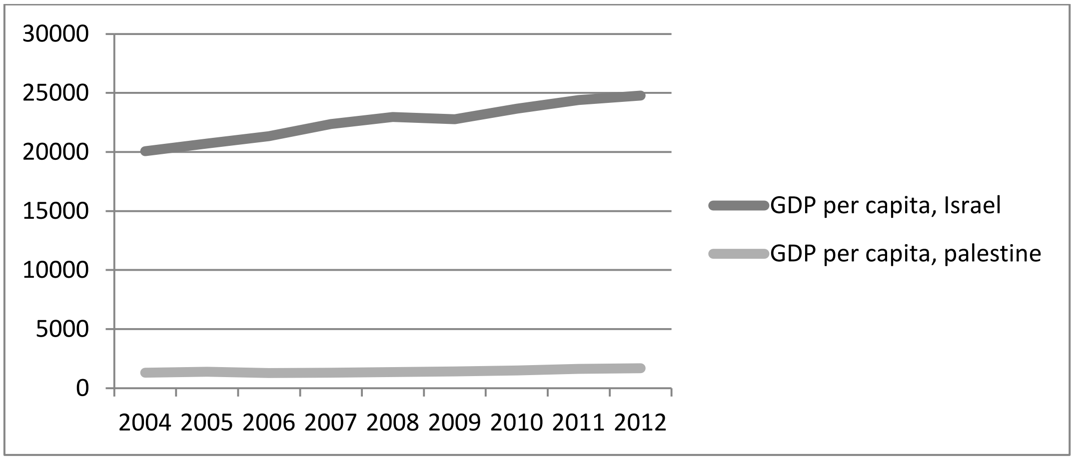
Source: PCBS. (2014). Energy balance in the Palestinian Territory for the years (2006-2012).

Figure 3: Average Electricity Monthly Consumption Per Household (kw.h)



Source: PCBS.(2014). Households energy surveys for the years 1999-2013.

Figure 4: Average Electricity Monthly Consumption Per Household (kw.h) [24]



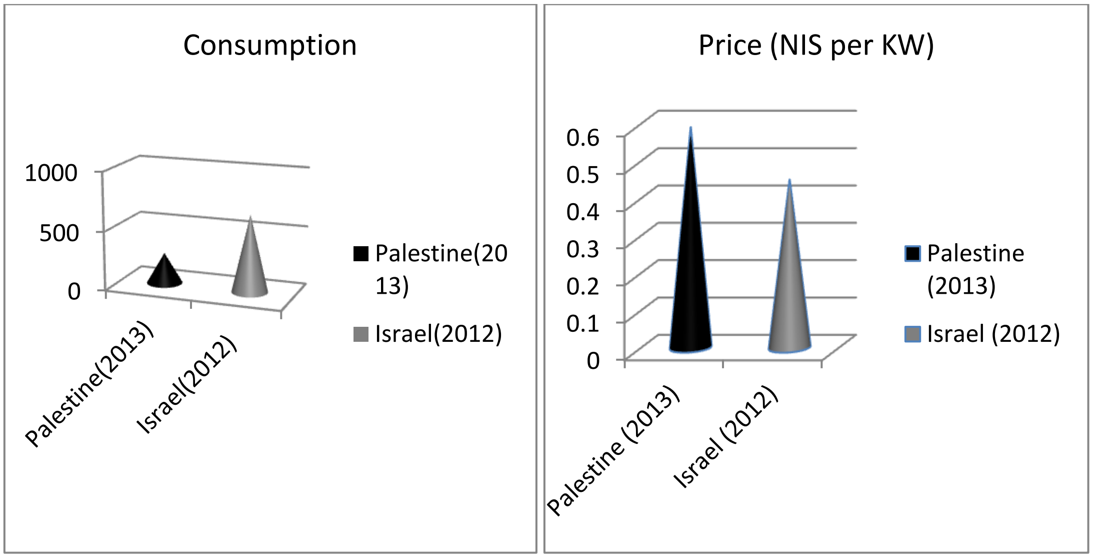
Sources: PCBS. (2014). National accounts at current and constant prices for the years 2004- 2012, and World Bank (WB). (2014). World Development Indicators for the years 2004-2012

Comparing Palestine with Israel, average monthly electricity consumption per household in Israel is higher but prices are lower given the GDP gap between them. Figure 4 shows GDP per capita differences between Palestine and Israel across the period 2004 to 2012.

GDP per capita for Israel is always higher, and GDP gap is increasing. In addition, Israeli electricity consumption is higher than Palestinian while prices are lower as shown in Figure 5. For Palestine, average electricity monthly consumption per household is 260 kwh at price of NIS 0.59 per kw in 2013. While for Israel the average of electricity monthly consumption per household is 657.4 kwh at price of NIS 0.45 per kw in 2012. This gives a strong motivation to the PA to seriously start producing solar energy to solve the problem of high prices and achieve independence and sustainability.

[24] GDP per capita for Israel is measured at constant 2005 S$ and for Palestine at constant 2004 US$.

Figure 5: Palestinian and Israeli Average Electricity Monthly Consumption Per Household (kwh) and Average Prices (NIS/kwh)



Sources: PCBS (2014). *Consumer's prices survey*. , JDECO. Ramallah office (personal contact) and IEC (personal contact) (2014)

4.3 Solar Energy in Palestine

There are different renewable energy sources such as solar, wind, biomass[25], water, wave and tidal energy. Each, using a special technique, is an alternative for non renewable sources used to produce electricity. And each country uses the suitable form of renewable energy that is available and feasible given the geographic and other features of the country. In Palestine, solar energy is the most feasible one in addition to small potential of using wind energy, biogas from landfill and animals. Solar energy generates energy in two different forms: photo-voltaic solar power plants which use photo-electric panels and solar thermal plants or concentrated solar power CSP which use mirrors or lenses. Solar thermal plants are cheaper and they save energy (Heal, 2009). One of most common uses of solar energy in Palestine is water heating. At each home of Palestine there are solar collectors on rooftops which

[25] Biomass is any material that comes from plants during the photosynthesis process, which is the reaction between air (Oxygen), water and sunlight to produce carbohydrates (Mckendry, 2002).

capture solar radiations which are used to heat water. Using solar energy will be very important to decrease dependency on traditional energy sources in addition to solar radiation utilization. It will be more important in summer as electricity expenditures double in winter (Abulkhair, 2006).

Palestine could be classified as one of countries of relatively high solar radiation intensity with a daily average of 5.4 kwh/m^2 (Ibrik and Mahmoud, 2005). On average the amount of solar radiations in spring and summer is twice that in autumn and winter given that the total sunshine duration in the whole year is about 2850h (Ibrik and Mahmoud, 2005). This energy must be used in things other than water heating. Indeed a project has been started but late and still at the micro level.

In 2012, the PEA launched the 'Renewable Energy General Strategy' which aims to produce about 10% from total domestic electricity consumption (demand) and 5% from total expected consumption by 2020 using renewable sources. From this 10%, 50% of energy generated is expected to be produced from solar energy and 50% from other available resources including wind energy and biogas (PWC, 2012). The main goals of this strategy are: achieving sustainability of renewable energy use, security and independency of energy supply, and social and economic development in Palestine (PWC, 2013). In addition to the commercial solar plants in Jericho and Tubas, in 2012 PEA has implemented solar energy act where private companies in the West Bank install home photo-voltaic (PV) solar arrays for household production and consumption to achieve their strategy goals. In fact, there are two different types of these arrays. The first type is special for schools, mosques, or any public building. In this type the corresponding electricity company provide the building with the PV solar arrays for free. Those buildings, let us say schools, will use electricity generated during work hours, and all production after that goes to the corresponding electricity company. The other type is where households buy those arrays. The domestic supply of energy by households can be sold to their respective electric companies. The program requires households to install an inward meter (which has a certain price) and an outward bound meter which supplies electricity to the network (at a higher price)[26]. Either households supply all energy generated to electricity company at a price of NIS 1.07 per kw and buy it again when needed at a price of NIS 0.55 per kw. Or they use energy produced and only extra production is sold to the company at a price of NIS 0.8 per kw, when they need more energy they buy it again from the company but with an extra fee of NIS 0.12 per kw. This price differential is supposed to encourage households tap into this idea. In addition, the payback period is about 7 to 8 years which also encourages households. However, as of November 2013 only 150 households each paid roughly $10 thousand for the installation of this system.

PEA sets a procedure that facilitates the installation of solar arrays. These arrays have batteries which save energy to use it later at night. Also arrays will be connected to electricity companies, extra electricity production will be sold to them and they will sell it again to households when needed at a certain price, which is supposed to be lower where PA must incur price differential (PNN, 2013). Each array consists of a group of panels. The panel capacity is measured by kilowatt peak (kwp)[27], each panel has a capacity up to 5kwp, and each 1 kwp produces about 1500 kwh per year and costs $3200 (PWC, 2012) and the cost is decreasing. The total production capacity of an individual array is the sum of total panels' capacity.

This project will be a good investment to all Palestinians. Furthermore, it will alleviate loads in electricity networks, it will be safer, cleaner, and will decrease Palestinian dependency on the IEC, in addition to its economic impact especially in public finance and external trade. Moreover, electricity generated using renewable sources is cheaper, on average producing 1 Kwh using renewable sources is 36% cheaper than using coal (Whittington, 2002).

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[26] It is now allowed to install a net metering system, whereby the meter reverses the reading when selling to the network; thus using the same price as the company charges.

[27] Kilowatt peak is a technical measurement of amount of power a solar panel would produce assuming full sun radiation.

4.4 Limitations of Implementing Solar Energy Program

There are many limitations or challenges which make the implementation of solar energy project difficult (JDECO,2013), here are some:

1. Solar arrays must be installed in a house with a sunny rooftop and keep them always clean to be more efficient.
2. The price of solar arrays is relatively high. Not all Palestinians households can pay to obtain them due to known bad economic situation. But this cost could be recovered in at most 8 years if households bear all cost and it could be recovered in a smaller number of years if there are government subsidies.
3. For consumers ‘households’ who install the system, they must not have any debt to the electricity company i.e. all duties must be paid. So those who didn’t pay their bills will not benefit from the program.
4. Any surplus production from solar arrays must be sold to Electricity Company, and only to it.
5. Solar energy or any renewable energy supply is interrupted. So the need for conventional energy sources still required as backup. IEC may raise the price of backup demand.

4.5 Political Economy of Renewable Energy in Palestine

The political economy of renewable energy in Palestine is an analysis of the behavior of different players and how each relates to this issue. There are some players who are organized and motivated by self interest; these players might lose from implementing PV program on the ground. The absence of political regulations, renewable energy plants, risk, financing ability and know-how might be considered to be barriers that prevent implementing solar energy program. But what is obvious is that implementing solar energy program has many benefits to Palestinian households and to Palestine as a whole. Establishing this program in a serious manner is full of uncertainty. To businesses, investing in this project might bring them big profits while it's risky. To consumers, it is costly in the short run while it is profitable in the long run.

The usage of solar energy in Palestine as a way to produce electricity has two basic advantages. First, solar arrays exploit the cheap costless energy from the sun, and produce electricity more than household daily needs which can be sold to the electricity company that will generate earnings to households. The second advantage is that this is one of the ways to reduce Palestinian dependency to Israel, so it is a way to alleviate the debt problem. In addition to household savings which will be gained from the program, the industrial sector will benefit from solar energy program as it consumes a large share from total electricity consumption (about 21%). This electricity consumption is a cost for firms, so the start of using renewable sources will decrease their dependency on conventional sources, which in turn reduces their cost especially in the long run; lower cost means lower prices.

Concerned groups might be with or against this project. The main concerned groups are Palestinian Electricity Companies, PEA, government of Israel, IEC, Palestinian consumers and Palestinian firms (especially large scale firms). Each group has interests and wants to generate political or economic benefits from this program, on the other hand there are laws and limitations that govern their behavior. Groups' interests are different and each competes with the other, and each of them lobbied decision makers to take decisions in their favor.

To Palestinian consumers, the cost of constructing solar arrays is moderately high. The high cost is prohibitive, that is why a financing scheme is necessary to enable households the installation of such systems[28]. But taking into consideration long run benefits, replacing electricity meters by these arrays is more beneficial to them. And the cost will be covered in few years (at most 8 years), after that positive saving will

[28] According to the PCBS, in 2011 per capita income (GDP per capita) was $2489 in nominal terms, and $1635 in real terms.

be achieved. In addition, most of Palestinian households still have not heard about solar energy program yet, so the need for public awareness is urgent to encourage them to tap into the program and convince them of the long run benefits they will gain. Table 2 shows yearly savings a typical Palestinian household could make when installing the PV arrays. Assuming the first system at which the household sell all electricity production to the corresponding electric company at a price of NIS 1.07 per kwh and buy it again at a price of NIS 0.55 per kwh, assuming also full capacity production. This typical household will gain about NIS 1500 per year, which is assumed to payback the cost of arrays (self paid, loans…). In addition to this expected savings households would make, another incentive to install PV arrays is the continuous increase in average electricity price. Figure 6 shows how average prices have increased during the period 2008-2013.

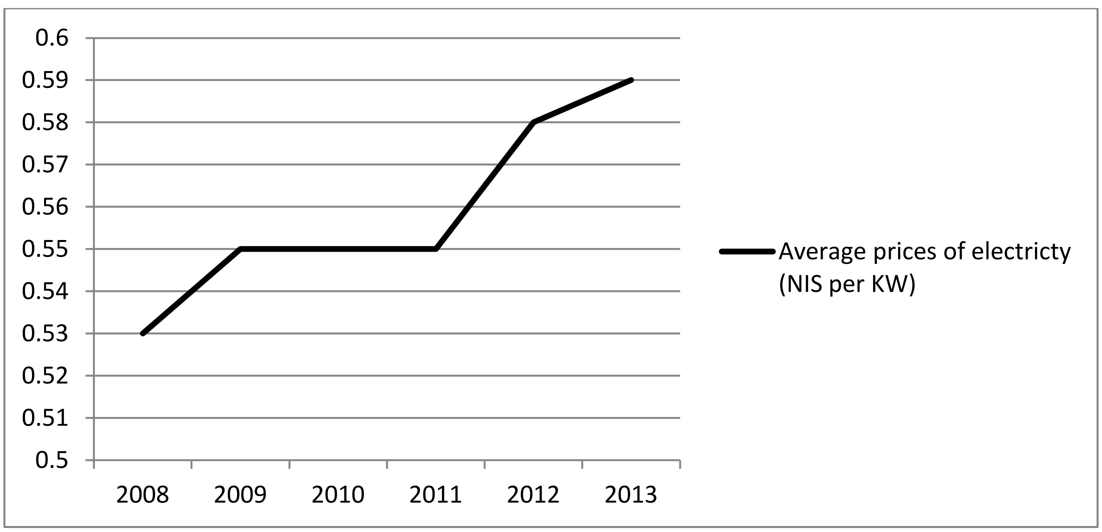
Table 2: Expected Annual Savings Generated if Households Engaged in Solar Energy System

Average monthly electricity consumption	260 kwh
Average annual electricity consumption	3120 kwh
Annual electricity bill	3120 $kwh * 0.59$=NIS 1841
1 kwp capacity	1500 kwh
Cost of two kwp	2*$3200=$6400
Price of electricity generated by solar arrays sold to EC	NIS 1.07 per kwh
Revenue from buying electricity production to EC	1.07*2*1500 kw=NIS3210
Price of buying electricity again from EC	NIS 0.55
Payments to EC	0.55*3120 kwh= NIS1716
Savings	NIS1494

Sources: PCBS.(2014). Households energy surveys for the years 1999-2013., JDECO. Ramallah office (personal contact) and PWC. (2012). *Palestine solar initiative.* Palestinian Energy and Natural Resources Authority.

The annual electricity bill for a typical Palestinian household is about NIS 1841. If they install the solar system then they have to sell the electricity production to the electric company, this will yield an annual revenue of NIS 3210. On the other hand, households will buy this production again when needed at a cost of about NIS 1716. The difference between what households sell the electricity production and buy it again from the electric company is expected to NIS 1494 which is the savings. This means that households will be winners from implementing the solar energy program. So they are expected to tap into the program, but the figures of the number of households who install the solar arrays still very small.

Figure 6: Consumers' Average Electricity Prices (NIS per KW)



Source: PCBS. (2014). Consumer's price surveys for the years 1999-2013.

To firms, using the same system used by households initially is feasible and profitable[29]. Given that the total industries' electricity consumption is $1{,}025{,}620 MW.h$. Table 3 shows the expected cost of using PV solar system by firms

[29] This assumption is hypothetical; firms must use another system than that used by households. In addition, home solar arrays might produce all of electricity needed by households, while firms' solar arrays will be used to generate a percent of their total electricity consumption.

according to some figures previously mentioned, and assuming a production capacity of 10% from total electricity used.

The industrial sector as a whole is expected to invest about $219 million in the solar energy program to produce about 10% of its' total electricity consumption using solar energy. The cost might be smaller and savings might be larger if a new system special for industries is installed.

Table 3: Expected Cost Incurred by All Industries if They Engaged in Solar Energy System

Total electricity consumption (industrial sector)	1,025,620 $MW.h$
Electricity generated using solar energy	10%
Panel production capacity	$5kwp$
1 kwp capacity	1500 $kw.h$
The cost of $1kwp$	$3200
Number of kwp needed	68,375
Cost of total kwp (panels)	$219 million
Industrial electricity consumption (share)[30]	20.89%
Industrial electricity consumption (volume)	$88million

Source: JDECO. Ramallah office (personal contact), PCBS. (2014). Energy balance in the Palestinian Territory for the years (2006-2012) and PWC. (2012). *Palestine solar initiative.* Palestinian Energy and Natural Resources Authority.

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[30] This value is for year 2012.

The annual electricity bill all industrial sector pay is $88 million. Installing solar array system that produces 10% of total electricity needed for the industrial sector will cost $219 million. But it will annually save this 10% which is about $9 million. So firms are also winners even that a serious solar energy program for the industrial sector is nonexistence.

The private sector is expected to invest in this program. Private sector was not allowed to invest in solar arrays until 2012, when the PEA launched the 'Renewable Energy General Strategy'. From one hand, if the private sector invest in the program they will gain profit from selling solar arrays. From the other hand, this profit will be lower if they have to pay taxes on these imported arrays. So, what determines whether the private sector is a winner or loser from this program is the value of the tax; and if households tap into the program and demand these arrays.

To Palestinian Electricity Company (EC), "solar energy program will never be a loss to Palestine or even to the whole World" as Engineer Thaer Jaradat said[31]. It is not just financially profitable; it also has a big environmental profit which is the most important. In addition, as Jaradat said solar energy program is a way to reduce (not eliminate) Palestinian dependency to Israel, so it is one of the ways to achieve or feeling that Palestinians achieve Sovereignty. In general, Palestinian electricity companies will benefit from solar energy program especially after Israeli court's decision to posses Jerusalem District Electricity Company (JDECO) bank accounts and real estate to ensure payment of the accumulated debt, which amounted to NIS 531 million in October 2013 (JDECO, 2014). If households install solar arrays, then this will benefit the electric companies since this will alleviate the unpaid electricity bills problem. In turn, the debt problem will also be alleviated. In addition, if households install the second solar arrays system at which they sell only extra production to the corresponding electric company, then the electric companies will

[31] Thaer Jaradat is an engineer who works at the Jerusalem District Electricity Company JDECO which was selected as a representative company of all other electricity company branches.

gain profit. Households will sell extra production to the electric company at a price of NIS 0.8, and they will buy it again when needed at a price of NIS 0.92 (a fee of NIS 0.12 to the electric company)But the question to be answered is why haven't the electric companies encourage renewable energy thus far?[32]

To PEA, their interests from implementing solar energy program is to achieve the 'Renewable Energy General Strategy' by 2020, in addition to economic and environmental benefits, energy security and interdependency as Falah Demery said[33]. He also said that there are technical, economic and political limitations the program faces. Technically, the program is feasible but it still needs more specialists and engineers. Economically, the big problem is the high fixed or initial cost, but as Demery mentioned, the small payback period must be taken into consideration and encourages households to buy these arrays. Politically, it is not obvious if there are political limitations, but Demery says that Government of Israel will neither easily accept to lose part of its electricity exports nor to accept the idea of achieving some Palestinian economic independency through the implementation of any of renewable energy programs.

To the PA, the program is profitable. In 2012, government of Israel deducted about NIS 55 million from customs clearances to the IEC (Sadaqa, 2012). Installing the system will reduce the debt problem as discussed previously, which means an additional revenue to the PA which is the part that is deducted from customs clearances.

The Israeli government's attitude towards exporting electricity to Palestinians may be mixed; on the one hand renewable energy may dampen the net lending problem, but at the same time reduces Israel hegemony over political talks with the Palestinian side. But it must realize that the remaining part of Palestinian electricity debt to IEC

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[32] No answer was given from the electric companies to this question.
[33] Engineer Falah Demery is a researcher in the energy research center at the PEA.

(debt to IEC has exceeds NIS 1 billion), which has not been deducted from VAT revenues, is borne by Israeli consumers (Barkat, 2013). So the program might benefit them economically but not politically. The Government of Israel wants to help PA but to serve their own political interests. While at the same time PA wants to solve the problems of discontinuity of electric supply and the interruption of customs' clearances transfers.

Despite the debate and the presence of all the different points of view of stakeholders in regards to renewable energy, and in spite of the benefits and the limitations of the solar energy project, at this stage the PA is expected to attract the attention of households, private sector and banks to the idea. In addition, the establishment of a special law for renewable energy and its uses is still needed.

4.6 Palestinian SAM

CGE PalMod model is calibrated on Palestinian SAM for the year 2011 (USAID, 2013). This study used 2011 SAM because it is the most recent matrix available. The data required for the SAM is available from the Palestinian Central Bureau of Statistics (PCBS) which was collected from different institutions including PCBS itself, Ministry of Finance (MOF), Ministry of National Economy (MNE) and International Monetary Fund (IMF).

Table 4 shows general 2011 SAM for Palestine. There are six main accounts in the Palestinian SAM: activities, commodities, factors of production, institutions, capital and ROW. For this SAM we will analyze the data points in Table 5 which shows the Palestinian SAM in numbers (in $ million).

1. Activities account

In Palestine, it is assumed that there are 16 branches of activities which are named in Table 6. Expenditure of activities' accounts include the value of intermediate inputs (INT) which reflects total values from commodities that is consumed by each activity as inputs, the value of intermediate inputs is $6000 million. Value of factors of production 'value added' which is wages for labor (WL) and rents for capital (RK), payments to factors of production is $7168 million. And indirect taxes paid by firms (TA) which equals to $48 million. Taxes are either taxes on factors of production which are taxes on labor and capital, or taxes on output (final product) which are VAT, customs and excise on domestic product and on imports, purchases tax and subsidies. Finally, the consumption of fixed capital i.e. depreciation (DEP) which is $631 million. The sum of all these values gives the total activities spending which equals to $13,847 million.

Table 4: Structure of Palestinian SAM

	Commodities	Branches of activity	Factors of production	House-holds	Firms	Government	Net taxes on products	Capital-Private	Capital-Public	Change in inventory	Rest of the World	TOTAL
Commodities		INT		CH		CG		I-ptivate	I-public	Δinv	E	demand
Branches of activity	SCA											Activities income
Factors of production		WL+RK									YROW	Factors income
Households			YH			TRHG					TRHROW	Households income
Firms												
Government				TRGH			tax				TRGROW	Governmen t revenues
Net taxes on products	TC	TA										Tax revenues
Capital-Private		DEP		SH		GS					SROW	Private savings
Capital-Public						GS						Public savings
Changes in the inventories								Δinv				Change in inventory
Rest of the World	M											Foreign exchange outflows
TOTAL	supply	Activities spending	Factors spending	Households' expenditure	0	Government spending	Taxes	Private investment	Public investment	Change in inventory	Foreign exchange inflows	

Source: USAID. (2013). *Report on the social accounting matrix for the PalMod model.* Investment Climate Imperovement Project.

Table 5: 2011 SAM for Palestine, million USD

	Commodities	Branches of activity	Factors of production	House-holds	Firms	Government	Net taxes on products	Capital-Private	Capital-Public	Change in inventory	Rest of the World	TOTAL
Commodities		6,000		9,432		2,920		1,650	370	-332	1,510	21,550
Branches of activity	13,847											13,847
Factors of production		7,168									750	7,917
Households			7,917			521					346	8,784
Firms												0
Government				141			1,977				859	2,977
Net taxes on products	1,928	48										1,977
Capital-Private		631		-789		-834					2,311	1,319
Capital-Public						370						370
Changes in the								-332				-332
Rest of the World	5,775											5,775
TOTAL	21,550	13,847	7,917	8,784	0	2,977	1,977	1,319	370	-332	5,775	

Source: USAID. (2013). *Report on the social accounting matrix for the PalMod model.* Investment Climate Imperovement Project.

2. Commodities account

Commodities account reflects supply and demand sides of economy. There are also 16 branches of commodities which are the same as branches of activities. Expenditure of this account includes value of domestic production from activities account which presents supply of commodities by activities (SCA) which equals to $13,847 million. Another component is Taxes on products (TC) such as sales tax which equals to $1,928 million. And total value of imports (M) which equals to $5,775 million. The sum of these values reflects the supply side of the economy, the total supply equals to $21,550 million.

Table 6: Branches of Activities

Agriculture, forestry and fishing
Mining and quarrying
Manufacturing
Electricity (black energy), gas, steam and air conditioning supply, water supply, sewerage, waste management and remediation activities
Construction
Wholesale and retail trade, repair of motor vehicles and motorcycles
Transportation and storage
Financial and insurance activities
Information and communication activities
Accommodation and food service activities
Real estate activities
Professional, scientific, technical activities, administrative and support service activities
Education
Human health and social work activities
Public administration and defense
Other service activities

Source: USAID. 2013. Report on the social accounting matrix for the PALMOD model.

3. Factors of production account

There are two factors of production: labor and capital. Expenditure of factors of production is income received by households (YH) assuming households are the owners of factors of production. More general, each of factors of production might be disaggregated into sub factors, e.g. labor might be split into skilled and unskilled labor or male and female. In the Palestinian SAM labor account is not split. Income received by households is $7,917 million.

4. Institutions account

Institutional account is composed of domestic economic agents: households, firms (businesses) and government.

- Households

Households account includes what households pay for commodities for private consumption (CH) which equals to $9432 million. Transfers to government (TRGH) which include taxes on income equals $141 million. And households' savings (SH) which equals to -$789 million.

- Firms

Firms account includes taxes which are transfers to government and savings, which are missing in Palestinian SAM. It also includes intermediate consumption which is calculated in activities account.

- Government

Here both columns 'Government' and 'Net taxes on products and production, taxes on factors of production' reflect the government account. Expenditure by government includes value of government consumption of commodities (CG) which is $2920 million. Transfers to households (TRHG) which include taxes refunds and social transfers equals $521 million. And government savings (GS) which equals to the sum of the transactions between the government and private and public capital accounts shown in the table above (-$464 million). Finally Net taxes on products and production, taxes on factors of production (tax) equals to $1977 million.

5. Capital account

Also called savings-investment account includes gross capital formation or investment , which is split into private capital and public capital , and change in inventory (Δ inv). For the Palestinian SAM private investment ($I_{private}$) equals \$1,650 million, public investment (I_{public}) equals \$370 million and the change in inventory is -\$332 million.

6. Rest of the world account

Rest of the world account reflects all transactions between all accounts of domestic economy and rest of the world. Rest of the world is split into Israel and the remaining rest of the world ROW. It includes data on exported commodities (E), total Palestinian exports to Israel and ROW is \$1,510 million, compensation of employees from rest of the world (YROW) which equals \$750 million, transfers to households (TRHROW) which equals \$346 million, transfers to government (TRGROW) which equals \$859 million, and foreign savings (SROW) which equals \$2,311 million. The sum of all transaction of the rest of the world account with other accounts is \$5,775 million which reflects foreign inflows.

4.7 Measuring Ratios

Another thing that could be calculated from the SAM which is important in describing the structure of the economy is the ratios. The matrix of ratios or matrix of coefficients has the same structure as the SAM but the values in the cells are measured by dividing the value of each cell by the sum of the corresponding row or column. For example, looking at table 3 above the coefficients of the branches of activities are measured by dividing the value of each cell in the branches of activities column by the sum of that column (activities spending or production expenditure). Each value shows the cost of inputs or factors of production or taxes per unit of total production expenditure. Those indicators are very important and widely used in policy analysis. For example if we divide the values of the branches of activities column on the total sum of that column, then we will obtain the following ratios: 43.3% which is the cost of intermediate inputs from the final value of total production (cost), 51.7% is the share of the cost of factors production from total cost, 0.35% is the share of taxes from total cost and 4.6% is depreciation rate. Similarly, if we divide the values of commodities column on the total sum of that column (total supply), then we will get 64.3% as the share of domestic production delivered to home market from total supply, 9% is the tax share and 26.7% the share of imports from total supply, and so on. In general, coefficients in this matrix are very important and widely used in analyzing economy.

Chapter 5: Model Specification

Our study will utilize the PalMod CGE model which is based on the Palestinian Social Accounting Matrix for the year 2011. The PalMod model includes four main agents: firms, households, government, and the rest of the world. There are 16 different branches of activities and commodities. And all agents are assumed to make optimization given their budget constraints.

5.1 Firms

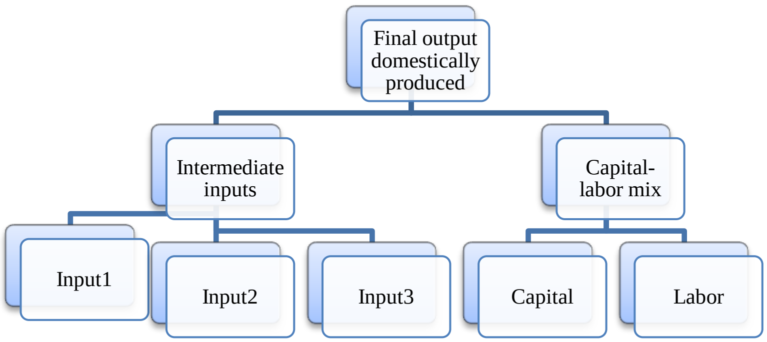
Firms are assumed to operate in a perfectly competitive market structure, and they are minimizing cost, given technology which is assumed to be a constant return to scale CRTS, in order to determine optimal levels of inputs and outputs. Each firm obtains its final output through two stages. In stage one a firm chooses the level of intermediate inputs and labor-capital mix according to a Leontief production function, which in our CGE modeling case doesn't allow for substitution between intermediate inputs (commodities) and labor-capital mix. And the value of the final output equals the value of intermediate inputs plus value added which is the value of labor and capital (labor-capital mix) that would be used in production process. In stage two value added is determined according to a constant elasticity of substitution (CES) function, at which the value of labor and capital would be determined each separately. Firm decision is illustrated in Figure7.

The capital-labor mix resulting from the Leontief production function is given by:

$$KL_s = \alpha KL_s . XD_s \qquad (1)$$

Where: KL_s is capital labor mix by branch s, αKL_s is a fixed Leontief coefficient, which is the share of capital-labor mix in production, given that Leontief function allows for different values of shares. XD_s is domestic production by branch s=1 ......16..

Figure 7: Production Decision



domestic production is allocated between activities (as inputs) and between different types of commodities (used for final consumption).

The total intermediate inputs used by industry s is the sum of all inputs used in the production from all other industries. It is given by:

$$IO_s = \sum_c io_{c,s}.XD_s(1 + trcc_c) \quad (2)$$

Where: IO_s is intermediate input used by industry s from all other industries, $io_{c,s}$ is technical coefficient between industry s and commodity c, which shows the share of a commodity c as intermediate inputs in industry s. $trcc_c$ is transaction costs on commodity c..

The optimal allocation of domestic production between different types of commodities is the sum of all shares of the production of commodity c produced by industry s:

$$XDDE_c = \sum_s ioC_{s,c}.XD_s \quad (3)$$

Where: $XDDE_c$ is domestic production to home and foreign markets, which is the value of final output that wasn't used by other industries as inputs. $ioC_{s,c}$ is share of domestic production to home and foreign markets by activity s and commodity c.

And the price of domestic production is given by:

$$PD_s = \sum ioC_{s,c}.PDDE_c \tag{4}$$

Where: PD_s is price of domestic production and $PDDE_c$ is price of domestic production to home and foreign markets.

Now if PKL_s is price of capital-labor mix and P_c is price of commodity c, then the value of domestic production is given by :

$$PD_s.XD_s = \sum_c \left[io_{c,s}.XD_s.P_c(1 + trcc_c)\right] + PKL_s.KL_s \tag{5}$$

Equation 5 shows the value of domestic production or final production which equals to the value of intermediate inputs used and value added i.e. the value of labor and capital. Labor and capital values are determined according to a constant elasticity of substitution (CES) function:

$$KL_s = \alpha F_s.TFP.(\gamma FK_s.(K_s/(1 + trcs_s))^{-\rho F_s} + \gamma FL_s.L_s^{-\rho F_s})^{-1/\rho F_s} \tag{6}$$

Where: αF_s is efficiency parameter of CES production function of the firm s, TFP is the total factor productivity, γFK_s is CES share parameter for capital, γFL_s is CES share parameter for labor, L_s is labor demand, K_s is capital demand and ρF_s is substitution parameter such that the elasticity of substitution (EOS) between capital and labor is given by: $\sigma F_s = {}^{1}/_{(1 + \rho F_s)}$.

Reasons behind the use of CES[34] function in PalMod are:

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[34] General form of a CES function is: $Y = A[\delta K^{-\rho} + (1 - \delta)L^{-\rho}]^{-\varepsilon/\rho}$, where Y is level of output, A is efficiency parameter such that $A > 0$, δ is distribution of share parameter, ρ is substitution parameter,

- CES function allows for different values of elasticity of substitution, while other functions such as Cobb-Douglas assumes that elasticity of substitution equals 1.
- CES function allows for different shares values.
- It has the property that it's a general form of special cases as Leontief, linear and Cobb-Douglas functions.

Each firm minimizes its cost function:

$$cost_s(K_s, L_s) = \left[PK_s.(1 + tk_s) + d_s.\left(PIT_{s=nsgv} + PITG_{s=sgv}\right)\right]$$
$$.K_s/(1 + trcs_s) \ + [PL.(1 + tl_s)].L_s \qquad (7)$$

Where: PK_s is return to capital, PL: wage rate, tk_s is tax rate on capital use, tl_s is tax rate on labor use, d_s is depreciation rate, $PIT_{s=nsgv}$ is price of composite investment in the private sector, $PITG_{s=sgv}$ is price of composite investment in the public sector, $trcs_s$[35] is transaction cost on activity s, sgv is subscript of education, human health and social work activities and public administration and $nsgv$ is subscript of all branches except education, human health and social work activities and public administration (13 branches).

Subject to its production technology[36] (equation 6) yields:

_Demand for capital which is a function of capital and labor prices:

ε is homogeneity parameter. And the elasticity of substitution σ is given by $\sigma = 1/(1+\rho)$, where $0 \leq \sigma \leq \infty$ (Elsenburg,2003). In CGE modeling, the production is assumed to be homogeneous of degree 1, $\varepsilon = 1$.

[35] Transaction cost is included in the equation since it reflects cost of implementation or installing a new machine, it is additional cost to capital. So it gives the real (effective) level of capital,

[36] In fact, a firm decision is to minimize its cost function subject to its production technology which is in general the relation between total output (intermediate input plus value added) and capital and labor used. But here, and almost in most literature the constraint is only the value added because intermediate input is assumed to be a fixed proportion from total output. And total output, i.e. GDP is just the value added.

K_s =$(KL_s/(\mathrm{TFP}.\alpha F_s/(1+trcs_s))).(\alpha FK_s/((1+tk_s).PK_s+d_s.$

$\left(PIT_{nsgv}+PITG_{sgv}\right)))^{\sigma F_s}.(\gamma FK_s^{\sigma F_s}.((1+tk_s).PK_s+d_s.(PIT_{nsgv}+$

$PITG_{sgv}))^{1-\sigma F_s}+\gamma FL_s^{\sigma F_s}.((1+tl_s).PL)^{1-\sigma F_s})^{(\sigma F_s/(1-\sigma F_s))}$ (8)

_Demand for labor which is also a function of capital and labor prices:

$$L_s = (KL_S/TFP.\alpha F_s).(\gamma FL_s/(1+tl_s))^{\sigma F_s}.\left(\gamma FK_s^{\sigma F_s}.(1+tk_s).PK_s+\right)d_s.$$
$$\left(PIT_{nsgv}+PITG_{sgv}\right))^{1-\sigma F_s}+\gamma FL_s^{\sigma F_s}.\left((1+tl_s).PL\right)^{1-\sigma F_s})^{(\sigma F_s/(1-\sigma F_s))} \quad (9)$$

_And the zero profit condition[37]:

$$PKL_s.KL_s = \left[PK_s.(1+tk_s)+d_s.\left(PIT_{s=nsgv}+PITG_{s=sgv}\right)\right].K_s/(1+trcs_s)+$$
$$[PL.(1+tl_s)].L_s \quad (10)$$

5.2 Households

Households are assumed to maximize their utilities according to their budget constraints to allocate between different commodities, in which there are 16 different commodities in this model. Households gain income from capital and labor and transfers from the government and from rest of the world . And they pay taxes on income gained domestically and from abroad.

Household income YH is given by:

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[37] The zero profit condition could be derived using Euler formula, since CES function used here is homogeneous of degree1. In general Euler formula is $\sum x_i f_i = kf$, where x_i is one of factors of production, f_i is marginal productivity of factor i, k is degree of homogeneity which equals 1, and f is production function which equals output Q. Suppose an economy uses only capital K and labor L in production, such that $Q=f(K,L)$ then applying Euler formula yields: $Kf_k+Lf_l=Q$, given that $f_k=dQ/dK$, and $f_l=dQ/dL$ then $Q=K(dQ/dK)+L(dQ/dL)$. Marginal value product of capital for example MVP_k equals to the value of production yields by using units of capital which is $P_Q.dQ/dK$, and maximizing profit means that MVP_k equals to the price of capital P_k. Now using this information Euler formula will be $P_Q.Q=P_K.K+P_L.L$.

$$YH = \sum_s (PK_s . K_s / (1 + trcs_s) + PL . (LS - UNEMP) + TRF + \big(TRHROW + YLW . (1 + trcl)\big) . ER \quad (11)$$

Where: LS is labor supply, $UNEMP$ is number of unemployed, TRF is total transfer received by the household, $TRHROW$ is total transfer received by the household from ROW, YLW is labor income from Israel, $trcl$ is transaction cost on labor and ER is exchange rate.

Household net (disposable) income YHD is given by:

$$YHD = (YH - ty . [YH - YLW . (1 + trcl) . ER] - tyf . YLW . (1 + trcl) . ER) \quad (12)$$

Where: ty is income tax rate on revenues from Palestine and tyf is income tax rate on revenues from abroad.

Household savings are given by:

$$SH = MPS . YHD \quad (13)$$

Where: SH is households' savings and MPS is marginal propensity to save.

After paying taxes and savings, households income for consumption i.e. disposable income $CBUD$ is given by:

$$CBUD = YHD - SH \quad (14)$$

Utility functions in this model are assumed to be in the form of Stone-Geary functions. Stone-Geary function assumes minimum level of subsistence must be consumed before allocate income between commodities and then determine the optimal level of a commodity to be consumed. Each household maximizes the following Stone-Geary utility function:

$$U(C_c) = \prod_c (C_c - \mu H_c)^{\alpha H_c} \quad (15)$$

Where: C_c is consumer demand for commodities, μH_c is subsistence level out of consumer demand for commodities and αH_c is marginal budget share for commodity c with $\sum_c \alpha H_c$=1.

Subject to budget constraint:

$$CBUD = \sum_c (1 + tvat_c + texc_c + tc_c - tsc_c).P_c.(1 + trcc_c).C_c \quad (16)$$

Where: $tvat_c$ is VAT rate on consumption, $texc_c$ is excise rate on consumption, tc_c is other taxes on products rate on consumption, and tsc_c is subsidies rate.

The value of consumer demand for commodity c, is given by equation (17) which shows the value of demand in a commodity c, expenditure on c, which equals to expenditure on the level of subsistence of the commodity plus expenditure share of the commodity from what remains from income after spending a portion of it in the level of subsistence in all other commodities cc:

$$P_c.(1 + trcc_c).(1 + tvac_c + texc_c + tc_c - tsc_c).C_c$$
$$= P_c.(1 + trcc_c).(1 + tvac_c + texc_c + tc_c - tsc_c).\mu H_c + \alpha H_c.[CBUD - \sum_{cc}(P_{cc}.(1 + trcc_{cc}).(1 + tvac_{cc} + texc_{cc} + tc_{cc} - tsc_{cc}).\mu H_{cc})] \quad (17)$$

5.3 Government

Total government revenue equals all different taxes collected plus all transfers from the rest of the world. While total government expenditure equals government consumption expenditure, government transfers, and subsides on consumption.

Total government revenue $GREV$ is given by:

$$GREV = TAXR + TRGROW.ER \quad (18)$$

Where: $TAXR$ is tax revenues and transfers received by government from ROW.

Below is description of all kinds of taxes collected by government:

There are three main types of taxes: tax on production and tariffs on imports $TRPROD$, current taxes on income and wealth $TRPROD$, and social contributions $TRSOCT$.

$$TAXR = TRPROD + TRPROP + TRSOCT \quad (19)$$

tax on production and tariffs on imports $TRPROD$ is the sum of taxes on households consumption TRC and taxes on imports $TRPRODM$.

$$TRPROD = TRC + TRPRODM \quad (20)$$

$$TRC = \sum_c [P_c.(1 + trcc_c).(tvat_c + texc_c + tc_c).C_c \quad (21)$$

$$TRPRODM = \sum_c ((tm_c + tmf_c + tvatf_c + texcf_c + tcf_c + tpurf_c).$$

$$(MROW_c.PMROW_c.(1 + trci_c).ER + MISR_c.PmISR_c.PCINDEX) \quad (22)$$

Where: tm_c is customs rate on consumption, tmf_c is customs rate on imports, $tvatf_c$ is VAT rate on imports, $texcf_c$ is excises rate on imports, tcf_c is other taxes on products rate on imports, $tpurf_c$ is purchase tax rate on imports, $MROW_c$ is demand of imports from ROW, $PMROW_c$ is world price of imports from ROW in foreign currency, $trci_c$ is transaction costs on imports, $MISR_c$ is demand of import from Israel, $PMISR_c$ is world price of imports from Israel in local currency, and $PCINDEX$ is consumer price index.

Current taxes on income and wealth $TRPROP$ is the sum of taxes on profits of corporations and other current taxes $TRPROPF$ and taxes on households income $TRPROPH$.

$$TRPROP = TRPROPF + TRPROPH \quad (23)$$

$$TRPROPF = \sum_c [tk_s.K_s.PK_s/(1 + trcs_s)] \quad (24)$$

$$TRPROPH = ty.[YH - YLW.(1 + trcl).ER] + tyf.YLW.(1 + trcl).ER \quad (25)$$

And total security contributions $TRSOCT$ is given by:

$$TRSOCT = \sum_s tl_s.L_s.PL \quad (26)$$

Total government expenditure $GEXP$ is given by:

$$GEXP = CGBUD.GDPDEF + IGTN + TRF - \sum_{sgv}[d_{sgv}.K_{sgv}.PIGT/(1 + trcs_{sgv})] \quad (27)$$

Where: $CGBUD$ is public final consumption expenditure, $GDPDEF$ is gross domestic product GDP deflator, $IGTN$ is total public investment, and d_{sgv} is depreciation rate in the public sector.

Public final consumption expenditure $CGBUD$ can be related to public demand for commodities CG_c as in the following equation:

$$CG_c.(1 + trcc_c) = \alpha CG_c.CGBUD \quad (28)$$

Where: αCG_c is share of consumption of commodity c in the total final consumption expenditure by the government.

Government final consumption expenditure as a share from GDP in real terms '$rCGBUDGDP$' is given by:

$$rCGBUDGDP = (CGBUD.GDPDEF.100)/GDPC \quad (29)$$

Where $GDPC$ is GDP at current prices, i.e. nominal GDP. And GDP is measured at constant prices, i.e. real GDP. Where GDP and $GDPC$ equations are written later in this chapter.

Transfers of the government are given by:

$$TRF = \sum_c[P_c.(1 + trcc_c).tsc_c.C_c] + TRHG.PCINDEX \quad (30)$$

Where: $TRHG$ Are transfers received by households from government.

Finally, government budget $SGBALN$ in nominal terms is the difference between government revenues and expenditures:

$$SGBALN = GREV - GEXP \quad (31)$$

$$SGBALN = SGBAL.GDPDEF \quad (32)$$

Where: $SGBAL$ is government budget (net lending or borrowing) in real terms.

Government budget to GDP ratio is given by:

$$rSGBALGDP = (SGBALN/GDPC).100 \quad (33)$$

5.4 The Rest of the World (ROW)

This sector reflects foreign trade. Palestine is assumed to be price taker, commodities are tradable, domestic and foreign commodities are imperfect substitutes. In addition, ROW is split into Israel and the ROW. Domestic consumers choose to allocate consumption between imported and domestic goods, which are imperfect substitutes, by minimizing the cost (expenditure) function given their CES demand function. As for export side, producers have the choice to export their production or supply it domestically. The optimal allocation is captured by maximizing total revenue given the supply function in which quantity supplied is split into quantity domestically supplied, and quantity to be exported abroad according to a constant elasticity of transformation (CET) function[38].

[38] CES and CET functions are the same. The difference is that in the function, substitution parameter ρ in the CES function is written combined with negative sign. While in CET function it is not combined with negative sign. That's mean, CES function is convex to the origin, while CET is concave to the origin (Elsenburg,2003). Indifference curves have CES form because diminishing marginal utility means convex indifference curves and isoquants . While production possibility frontier requires CET function because of increasing opportunity cost implies that functions are concave.

Import side:

At the first stage domestic consumers choose to allocate between domestically and imported products according to Armington function . They minimize cost function, which reflects what they pay for commodities that are domestically produced and imported from abroad:

$$cost_c(XDD_c, M_c) = PDD_c.XDD_c + PM_c.M_c \tag{34}$$

Where: XDD_c is domestic output delivered to home market, M_c is imports, PDD_c is price of domestic output delivered to home market and PM_c is price of imports in national currency.

Subject to their composite demand X_c which is CES function:

$$X_c = (\alpha A_c/(1 + trcc_c)).((1 - \gamma A_c).XDD_c^{-\rho A_c} + \gamma A_c.M_c^{-\rho A_c})^{-1/\rho A_c} \tag{35}$$

Where: αA_c is efficiency parameter in the Armington function for commodity c, γA_c is CES distribution parameter for total imports, and ρA_c is a parameter such that elasticity of substitution σA_c between domestic and imported goods is given by $\sigma A_c = 1/(1 + \rho A_c)$. Equation 35 shows that the composite demand is a function of both domestically produced and imported commodities.

Optimization yields:

Demand for imports which depends on the relative price ratio of composite demand and import:

$$M_c = X_c.(1 + trcc_c).(P_c/PM_c)^{\sigma A_c}.\gamma A_c^{\sigma A_c}.\alpha A_c^{\sigma A_c - 1} \tag{36}$$

Demand for domestically produced goods, which depend on the relative price ratio of composite demand and domestic production:

$$XDD_c = X_c.(1 + trcc_c).(P_c/PDD_c)^{\sigma A_c}.(1 - \gamma A_c)^{\sigma A_c}.\alpha A_c^{\sigma A_c - 1} \quad (37)$$

And zero profit function:

$$P_c.(1 + trcc_c).X_c = PDD_c.XDD_c + PM_c.M_c \quad (38)$$

At the second stage domestic consumer choose to allocate imports between Israel and ROW according to Armington function. They minimize cost function:

$$cost_c(MISR_c, MROW_c) = PMISR_c.MISR_c + PMROW_c.MROW_c \quad (39)$$

This cost function is the total expenditure that is paid to imports from Israel and from abroad.

Where: $PMISR_c$ world price of imports from Israel in local currency, and $PMROW_c$ is world price of imports from ROW in local currency.

Subject to import CES function:

$$M_c = \alpha AM_c.(\gamma A1_c.MISR_c^{-\rho AM_c} + \gamma A2_c.MROW_c^{-\rho AM_c})^{-1/(\rho AM_c)} \quad (40)$$

Where: αAM_c is efficiency parameter in the Armington function for imports, $\gamma A1_c$ is CES distribution parameter for imports from Israel, $\gamma A2_c$ is CES distribution parameter for imports from ROW, and ρAM_c is a parameter such that the constant elasticity of substitution σAM_c between imports from Israel and ROW is given by: $\sigma AM_c = 1/(1 + \rho AM_c)$.

Optimization yields:

Demand for imports from Israel which depends on the ratio of the price of total imports to the price of imports from Israel:

$$MISR_c = M_c.(PM_c/PMISR_c)^{\sigma AM_c}.\gamma A1_c^{\rho AM_c}.\alpha AM_c^{\rho AM_c - 1} \quad (41)$$

Demand for imports from ROW which depends on the ratio of the price of total imports to the price of imports from ROW:

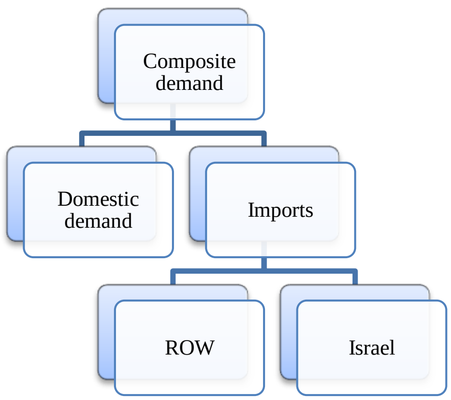
$$MROW_c = M_c.(PM_c/PMROW_c)^{\sigma AM_c}.\gamma A2_c^{\rho AM_c}.\alpha AM_c^{\rho AM_c - 1} \quad (42)$$

And zero profit condition:

$$PM_c.M_c = PMISR_c.MISR_c + PMROW_c.MROW_c \quad (43)$$

Figure8 shows Armington specification of domestic demand.

Figure 8: Armington Specification for Demand of Composite Commodities



Export side:

Export decision is illustrated in Figure 9. Similarly, at the first stage domestic producers choose to allocate between domestically supply and export products according to Armington function . They maximize total revenue function:

$$revenue_c(XDD_c, E_c) = PDD_c.XDD_c + PE_c.E_c \quad (44)$$

Revenue function shows the total revenue domestic producers gained from selling commodities domestically and selling to abroad.

Where: E_c is exports and PE_c is price of exports.

Subject to the following CET supply function:

$$XDDE_c = \alpha T_c.((1-\gamma T_c).XDD_c^{-\rho T_c} + \gamma T_c.E_c^{-\rho T_c})^{-1/\rho T_c} \quad (45)$$

Where: $XDDE_c$ is domestic products delivered to home and foreign markets, αT_c is efficiency parameter in the CET supply function, γT_c is CET distribution parameter for total exports, and ρT_c is parameter such that elasticity of transformation EOT σT_c is given by: $\sigma T_c = 1/(1+\rho T_c)$.

Optimization yields:

Supply of exports by domestic producers which depends on the price of domestic production to the price of exports:

$$E_c = XDDE_c.(PDDE_c/PE_c)^{\sigma T_c}.(1-\gamma T_c)^{\sigma T_c}.\alpha T_c^{\sigma T_c - 1} \quad (46)$$

Supply to domestic markets by domestic producers which depends on the price of domestic production to the price of domestic production supplied to home market:

$$XDD_c = XDDE_c.(PDDE_c/PDD_c)^{\sigma T_c}.\gamma T_c^{\sigma T_c}.\alpha T_c^{\sigma T_c - 1} \quad (47)$$

And zero profit function:

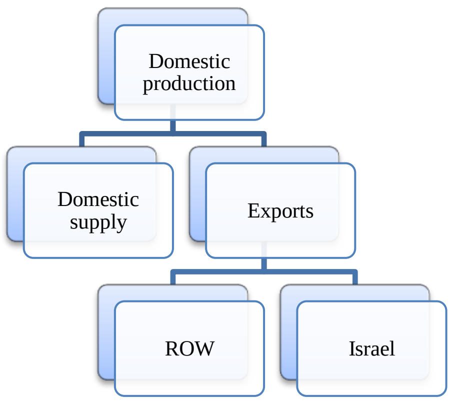
$$PDDE_c.XDDE_c = PE_c.E_c + PDD_c.XDD_c \quad (48)$$

In the second stage, the following is a CET function which shows how exports are allocated between Israel and ROW:

$$E_c = \alpha TE_c.(\gamma T1_c.EISR_c^{-\rho TE_c} + \gamma T2_c.EROW_c^{-\rho TE_c})^{-1/(\rho TE_c)} \quad (49)$$

Where: αTE_c is efficiency parameter for exports, $\gamma T1_c$ is CET distribution parameter for exports to Israel, $\gamma T2_c$ is CET distribution parameter for exports to ROW, $EISR_c$ is supply of exports to Israel, $EROW_c$ is supply of exports to ROW, and ρTE_c is parameter such that elasticity of transformation σTE_c of exports between Israel and ROW is given by: $\sigma TE_c = 1/(1+\rho TE_c)$.

Figure 9: Armington Specification for Supply of Domestically Produced Commodities



Maximizing revenue function subject to equation (49):

$$revenue_c(EISR_c, EROW_c) = PEISR_c.EISR_c + PEROW_c.EROW_c \tag{50}$$

Where: $PEISR_c$ is world price of exports to Israel in local currency and $PEROW_c$ is world price of exports to ROW in local currency.

Yields:

Supply of exports to Israel which depends on the price ratio of exports and exports to Israel:

$$EISR_c = E_c.(PE_c/PEISR_c)^{\sigma TE_c}.\gamma T1_c^{\rho TE_c}.\alpha TE_c^{\rho TE_c - 1} \tag{51}$$

Supply of exports to ROW which depends on the price ratio of exports and exports to the ROW:

$$EROW_c = E_c.(PE_c/PEROW_c)^{\sigma TE_c}.\gamma T2_c^{\rho TE_c}.\alpha TE_c^{\rho TE_c - 1} \tag{52}$$

And zero profit function:

$$PE_c.E_c = PEISR_c.EISR_c + PEROW_c.EROW_c \tag{53}$$

Finally, the balance of payment, which reflects all trade and capital flows, is given by:

$$\sum_c [MROW_c.(1 + trci_c).PWMROW_c + MISR_c.PWMISR_c.PCINDEX/ER] =$$

$$\sum_c EROW_c.(1 - trce_c).PWEROW_c + EISR_c.PWEISR_c.PCINDEX/ER +$$

$$YLW.(1 + trcl) + TRHROW + TRGROW + SWISR.PCINDEX/ER + SWROW \tag{54}$$

Where: $PWEROW_c$ is world price of exports to ROW in foreign currency, $PWEISR_c$ is world price of exports to Israel in local currency, $trci_c$ is transaction cost of imports, $trce_c$ is transaction costs of exports, $trcl_c$ is transaction costs of labor, $SWISR$ is foreign savings from Israel, and $SWROW$ is foreign savings from ROW.

5.5 Investment Demand

Total savings includes households' savings, firms' savings, government's savings which is the value of government budget or net lending (revenues-expenditures) and savings from ROW. Total savings S are given by:

$$S = SH + \sum_{nsgv}\left[d_{nsgv}.K_{nsgv}.PIT/\left(1 + trcs_{nsgv}\right)\right] + SGBAL.GDPDEF + SWISR.PCINDEX + SWROW.ER \tag{55}$$

Total investment is either private or public. Private sectors choose to allocate private investments between different commodities according to Leontief function:

$$I_c.(1 + trcc_c) = \alpha I_c.ITT \tag{56}$$

Where: I_c is private investment demand for commodities, αI_c is share of private investment for commodity c, and ITT is total private investment in real terms.

The value of private investment by branch of activity $nsgv$ which are non public activities '$INVPv_{nsgv}$' is a share of total private investment:

$$INVPv_{nsgv} = ShINV_{nsgv}.ITT \quad (57)$$

The price of composite investment in the private sector PIT is:

$$PIT = \sum_c \alpha I_c(1 + trcc_c).P_c \quad (58)$$

And value of total private investment equals to total savings less total value of stock variation/change in inventory SV_c in all branches:

$$PIT.ITT = S - \sum_c P_c.(1 + trcc_c).SV_c \quad (59)$$

Similarly, public sector (government) chooses to allocate its investment between different commodities according to Leontief function:

$$IG_c.(1 + trcc_c) = \alpha IG_c.IGT \quad (60)$$

Where: IG_c is public investment demand for commodities, αIG_c is share of public investments for commodity c, and IGT is total public investments in real terms. Nominal public investment $IGTN$ is: $IGTN = IGT.PIGT$, where $PIGT$ is price of total investment in the public sector, and it is given by: $PIGT = \sum_c \alpha IG_c.(1 + trcc_c).P_c$

Finally, the value of public investment in the three previously mentioned sectors: education, human health and social work activities and public administration , '$INVPb_{sgv}$' is a share '$ioINVPb_{sgv}$'from total public investment:

$$INVPb_{sgv} = ioINVPb_{sgv}.IGT \quad (61)$$

5.6 Price Equations

In CGE modeling, relative prices can be determined only. In PalMod GDP deflator $GDPDEF$ is chosen to be the numeraire[39]. This section shows how prices are related to each other. It also shows that prices of exports and imports in local currency are modification of world prices taking into account transaction costs, taxes and exchange rate.

From equation 53 domestic price of total export is given by:

$$PE_c = (PEISR_c . EISR_c + PEROW_c . EROW_c)/E_c \tag{62}$$

Price of exports to Israel in local currency $PEISR_c$ equals to the world price of exports to Israel multiplied by consumer price index $PCINDEX$.

$$PEISR_c = PWEISR_c . PCINDEX \tag{63}$$

And the world price of exports to ROW is adjusted to obtain price of exports to ROW in terms of local currency.

$$PEROW_c = PWEROW_c . (1 - trce_c). ER \tag{64}$$

This gives world export prices PWE_c:

$$PWE_c = (PWEISR_c . EISR_c + PWIROW_c . EROW_c)/E_c \tag{65}$$

From equation 43 domestic price for total imports PM_c is given by:

$$PM_c = (PMISR_c . MISR_c + PMROW_c . MROW_c)/M_c \tag{66}$$

Also domestic price of imports from Israel $PMISR_c$ equals to the world price of imports to Israel $PWMISR_c$ adjusted after paying all taxes on imports, it is given by:

[39] $GDPDEF$=1 and all other prices are determined with relative to it. If for example $P_1 = 5$ then that's mean $P_1 = 5$ times $GDPDEF$.

$PMISR_c =$
$PWMISR_c.(1 + tm_c + tmf_c + tvat_c + texcf_c + tcf_c + tpurf_c).PCINDEX$ (67)

And domestic price of imports from ROW $PMROW_c$ is given by:

$$PMROW_c = PWMROW_c.(1 + trci_c).(1 + tm_c + tmf_c + tvat_c + texcf_c + tcf_c + tpurf_c).E \quad (68)$$

Finally, the world import PWM_c is given by:

$$PWM_c = [PWMISR_c.MISR_c + PWMROW_c.MROW_c]/M_c \quad (69)$$

The consumer price index $PCINDEX$ is a Laspeyers index and is given by:

$$PCINDEX = \sum_c [(1 + tvat_c + texc_c + tc_c - tsc_c).P_c.(1 + trcc_c).C_c] / \sum_c [(1 + tvatz_c + texcz_c + tcz_c - tscz_c).PZ_c.(\, trcc_c).CZ_c] \quad (70)$$

Where: CZ_c, $tvatz_c$, $texcz_c$, tcz_c, $tscz_c$ and PZ_c are benchmark levels of private consumption, VAT rate on consumption, excises rate on consumption, other taxes on product rate, subsidies rate and price index of commodity c respectively.

5.7 Labor Market

The relation between labor supply LS and labor demand L_s by branch s is :

$$LS = \sum_s L_s + UNEMP \quad (71)$$

Labor supply which is also 'labor force' is the sum of total number of employed in all economic activities plus the number of unemployed.

And Phillips curve, which shows the relationship between unemployment level and inflation, is given by:

$$\frac{(PL/PCINDEX)}{(PLZ/PCINDEXZ)} - 1 = phillips. \frac{(UNEMP/LS)}{(UNEMOZ)/LSZ)} \quad (72)$$

Where: PLZ, $PCINDEXZ$, $UNEMOZ$ and LSZ are benchmark levels of wage rate, consumer price index, number of unemployed and labor supply respectively. And $phillips$ is Phillips parameter, which is set to be 0.1[40].

5.8 Market Clearing Equations

In CGE modeling, supply must equal demand in all markets. For a commodity c, its total supply X_c equals its total demand which consist of: demand for intermediate inputs $\sum_s IO_{c,s}$, private demand C_c, public demand CG_c, private investment I_c, public investment IG_c and change in inventories SV_c.

$$X_c = \sum_s IO_{c,s} + C_c + CG_c + I_c + IG_c + SV_c \quad (73)$$

Given that: $SV_c = svr_c . X_c$ (74)

Where: svr_c is share of inventories in domestic sales X_c.

5.9 GDP Equations

GDP at current prices is given by:

$$GDPC = \sum_c (((1 + tvac_c + texc_c + tc_c - tsc_c). C_c + CG_c + I_c + IG_c + SV_c). P_c.$$

$$(1 + trcc_c) + EROW_c. (1 - trce_c). PWEROW_c. ER + EISR_c. PWEISR_c. PCINDEX$$

$$-MROW_c. PWMROW_c. (1 - trce_c). ER - MISR_c. PWMISR_c. PCINDEX) \quad (75)$$

This is the familiar GDP equation which equals to the values of private consumption, government expenditure, total investment, which is private and public investment plus change in inventory, and net export, Which is measured at current prices.

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[40] This is the value that was used in the PalMod.

GDP at base year prices is given by:

$$GDP = \sum_{c}[[(1 + tvacz_c + texcz_c + tcz_c - tscz_c).C_c + CG_c + I_c + IG_c + SV_c]$$

$$.PZ_c.(1 + trcc_c) + EROW_c.(1 - trce_c).PWEROWZ_c.ERZ + EISR_c$$

$$.PWEISRZ_c.PCINDEXZ - MROW_c.PWMROWZ_c.(1 - trce_c).ERZ - MISR_c$$

$$.PWMISRZ_c.PCINDEXZ] \tag{76}$$

Which is in other term real GDP, and it is measured at constant prices i.e. benchmark prices.

Finally GDP deflator is the ratio of nominal GDP to real GDP:

$$GDPFEF = GDPC/GDP \tag{77}$$

Full details about derivation of production, consumption and rest of the world models are shown in appendix A.1.

Chapter 6: Empirical Results

This section describes different scenarios assumed to show the economic impact of implementing the solar energy program in Palestine. First, we look at two different approaches, the first approach assumes changes in the electricity sector which reflects electricity generated from black energy. And the second approach assumes an addition of a new sector which reflects electricity generated from solar energy. The two scenarios under the first approach are shocks to exogenous variables, and a third scenario is a combination of both. The three main scenarios where obtained under the first approach; scenario1 assumes an increase of TFP. Scenario 2 assumes an increase in the excise tax on electricity imports. Scenario 3 combines scenarios 1 and 2, it assumes an increase of both total factor productivity and excise tax of electricity imports. Naturally, it would seem that a disaggregation of the model in energy production would be a subsequent step to improve on the results at hand. In that case, renewable energy production can be an exogenous variable which can be increased to meet new demand without shocking the tariff on imported electricity from Israel; in the meantime, a shock on the tariff would have potentially different implications in the area of prices, trade, and public finance. This is a caveat that requires careful attention when interpreting the results of the model. In the second approach, we alter the SAM and equations to include solar energy production as an exogenous variable, whereby total energy consumption is from both green and black sources. Two main scenarios were outlined here; the first alters the SAM only, followed by a 10% increase in domestic electricity production from solar energy. And the second alters the SAM and equations[41] for imports, domestic demand and supply of electricity, it is also followed by an increase in domestic production. Below is a description of each approach and its expected results on the economy.

[41] See chapter 4 and 5 for further details on the SAM and the model

6.1 The Analysis of Changes in Domestic Electricity Sector (The First Approach)

Under this approach, we mimic shocks to the model that are expected to have similar effect on electricity production and imports. The idea here is that the black energy sector will utilize existing infrastructure without the investment for renewable energy. We also do not alter the structure of the PalMod model.

6.1.1 Scenario1: An Increase of Total Factor Productivity

TFP is added to the production function to account for changes in output resulting from changes stemming from sources other than labor and capital; in other words, TFP is added to the production function to capture the effect of changes such as technological changes (Comin, 2006). So a technological improvement or changes in the electric sector is captured by the TFP in the production function for electricity. The increase in productivity lowers the cost of production thus reflecting a similar effect to an increase in green energy. This scenario assumes an increase of TFP by 10%, which raises electricity domestic production by about 10%. This matches the 'Renewable Energy General Strategy' which aims to produce about 10% from total domestic electricity production by 2020 using renewable sources.

The increase in TFP leads to an increase in output (domestic production), which means hiring more capital and labor. Both labor demand and capital demand will increase which will lead to an increase in gains (income) at the old prices level, i.e., households' income will increase. The increase in households' total income will tend to increase disposable income and savings. In the meantime, the increase in TFP has a supply side effect, If domestic prices decrease then imports will decrease (depending on the degree of substitution between domestic production and imports)[42], and if income increases imports will increase. Net effect depends on which effect is the stronger.

[42] Notice that we assume in the model that domestic production and imports are imperfect substitutes.

Increase in capital demand will lead to an increase in taxes on corporate profit. Similarly, the increase in labor demand will lead to an increase in total social contributions. Both of these factors will lead to an increase in government revenues. The government will face the same electricity prices as the public, which means government will demand more, i.e., an increase in government final consumption expenditure which is part of government total expenditure. The net effect on government budget depends on the value of changes in government revenues and expenditures. As for the labor market, labor demand is expected to increase due to increase in domestic production. Real wages are expected to decrease due to increase in the general price level, and increase due to the increase in demand for labor.

6.1.2 Scenario 2: An increase of Excise Tax on Electricity Imports

This scenario shows the effects of an increase in excise tax on electricity imports[43]. Since imports in our model are endogenous, they cannot be reduced unless exogenized. Therefore, the exogenous variable that is shocked here is the excise tax on the electricity imports $texcf_c$, which, will reduce imports. $texcf_c$ is assumed to increase by 10%. As will be shown in the results, this 10% increase in the $texcf_c$ will cause electricity imports to decrease by about 6%.

The expected results from increasing $texcf_c$ are as follows: if $texcf_c$ increases, then taxes and duties on imports will increase causing government revenue to increase. Price of imported electricity from Israel and price of imported electricity from the rest of the world will all increase. The government will also face this increase in prices which will cause government expenditure to increase. Again, the final effect on the government budget depends on the magnitude of changes in government revenues and expenditures. The increase in import prices will cause total imports and electricity imports to decrease, both from Israel and from the rest of the world.

[43] This scenario is hypothetical because the quasi customs union with Israel controls this rate, and the PA is not allowed to change it. We add it as a proxy for a decrease in imports and because we think it might give interesting results.

Domestic output which is delivered to the home market will also increase. An increase in domestic production will cause the value added to increase, which in turn increases the demand for labor and capital. The increase in labor and capital income has a positive effect on households' income, disposable income and savings to go up.

6.1.3 Scenario 3: Increase of Both Excise Tax on Imports and Total Factor Productivity

This scenario combines scenarios 1 and 2 together. It assumes an increase of electricity domestic production (i.e. an increase in TFP) by 10%. This increase in domestic production is combined with government intervention, i.e., an increase of taxes on electricity imports by 10%. The effect of this scenario on economic variables is expected to be the sum of the individual effects when total factor productivity and taxes on electricity imports change separately.

6.1.4 Simulation Results

Table 7 shows the results obtained from simulations under the three different scenarios of the first approach. The first column in Table 7 is the value of each variable in the benchmark scenario. Each of the three subsequent columns shows the percentage change in the benchmark due to that scenario. For example, all scenarios show an increase in both government revenues and expenditures, with a larger increase in revenues which implies a decrease in the deficit. The benchmark values are in US million dollars except prices. Prices have no unit of measurement, since as mentioned before, these are relative prices. In what follows, we show a detailed account of impact of each scenario on four important items: public finance, trade, labor market and households socio-economic status.

Table 7: Results of the Three Scenarios of the First Approach Compared with the Benchmark[44]

Variable	Benchmark ($million)	Scenario1 (%)	Scenario2 (%)	Scenario3 (%)
Total government revenues	2976.87	0.28	0.71	0.99
Total tax revenues	2117.49	0.4	1	1.39
Total government expenditures	3665.99	0.21	0.62	0.83
Government deficit	689.12	-0.09	-0.23	-0.138
Electricity imports from Israel	425.57	0.76	-6.07	-5.37
Electricity imports prices from Israel	1.08	-0.03	9.37	9.32
Domestic production of electricity	292.37	9.16	-0.17	8.9
Electricity domestic prices	1	-9.34	1.31	-8.12
Electricity domestic sales	427.66	3.88	-3.86	-0.18
Employment for electricity	23.21	-3.9	-0.92	-4.8
Total employment	3252.69	1.31	-10.04	-8.9
Real wages	1000	0.04	0.04	0.07
Labor demand	3252.69	1.18	-10.17	-9.13
Households' total income	8783.7	0.36	-0.74	-0.4

Public finance

The impact on public finance is as expected. Under the three scenarios government revenues and government expenditure will increase, causing government budget deficit to decrease (the increase in government revenues is greater than the increase in government consumption and expenditures). Specifically, if TFP increases by 10%, then government revenues will increase by 0.28% resulting from the increase in both labor and capital demand hence income. The increase in TFP lowers cost (hence prices); this leads to increased government consumption and expenditure by 0.21%.

[44] Electricity sector includes electricity, gas, steam and air conditioning supply, water supply, sewerage, waste management and remediation activities. The value of imports for this sector is $425.57 million. But given that the value of electricity imports are $420 million, then the value of the imports of the other things is about $5 million which is very small with relative to electricity imports. We talk about electricity imports from Israel since it account for 96% from total electricity imports.

The change in government revenues exceeds the change in government expenditure causing government budget deficit[45] to decrease by 0.09%.

Increasing excise tax on imports by 10% has a different effect. Total tax revenues will increase by 1%,total revenues increase by 0.71%, and expenditures rise by 0.62% (due to the fact that government faces price increase). Again, the change in government revenues is greater than the change in government expenditure causing government budget deficit to decrease by 0.23%. The impact on government revenues and expenditures is similar in scenario 3 to scenarios 1 and 2. The impact, however is deeper. Changes in government revenues and expenditures are due to the same reasons mentioned in scenarios 1 and 2. When both TFP and excise tax increase by 10% then government revenues will increase by 0.99% and government expenditure will increase by 0.83% causing government budget deficit to decrease by 0.138%. This value (value of scenario 3) is between values of scenario 1 and 2, since under scenario 1 where changes in revenues and expenditure are less than scenario 2. And scenario 3 combines both of them, given that deficit is the difference between revenues and expenditure.

External trade

An increase in TFP by 10% improves the efficiency in electricity production domestically. This lowers the price of electricity produced domestically, and as a result domestic sales increase. This raises household's total income which in turn raises electricity imports from Israel. Domestic electricity production increases by 9.16%, the prices of electricity produced domestically declines by 9.36%, and electricity imports from Israel increases by 0.76%.

[45] The percent change in government deficit does not equal to the difference between revenues and expenditures percent changes. Instead, it could be measured by calculating new revenues and expenditures and then new deficit.

The analysis of the excise tax scenario is more complex. On the one hand, an increase of $texcf_c$ by 10%, increases imported electricity price by 9.37% causing electricity imports from Israel to decrease by 6.07%. This increase in the relative price of imported electricity causes people to switch to domestic electricity. On the other hand, the excise tax raises wages (connected to price changes) which increases the cost of producing energy; as a result, domestic production falls. Domestic electricity price will increase by 1.31% resulting in a decrease in domestic electricity production by 0.17%. Another reason behind the decrease in domestic production is that it is not competitive to the foreign production. If the government imposed this 10% excise tax on imports and subsidized the domestic production of electricity (5% increase for example), then domestic production will increase by 0.33%, and imports will decrease by 2.7%[46].

The effect of scenario 3 is the sum of the effects of an increase in TFP and the increase in taxes on imports. As explained in scenario 1 and 2, a 10% increase in TFP will cause electricity imports to increase, while a 10% increase in excise tax on electricity imports will cause electricity imports to decrease (due to increase in imported electricity prices). The final effect will be a decrease in electricity imports by 5.37%.

Labor market

The units of measurement for the SAM are all in $ million, there is no data on the number of employees and unemployment level. So in this section, employment in the electricity sector, total employment, wages and labor demand are used to analyze effects on the labor market. Employment here refers to what laborers received from the different activities. The results in Table 7 show that the effect on employment in the electricity sector is negative under all scenarios, and the same holds for employment in all sectors except for scenario 1. Under scenario 1, the improvement

[46] This figures are obtained from shocking the model (Scenario 2 with subsidy).

in TFP reduces the overall price level leading to an increase in real wages. But also the demand for workers will increase through the increase of domestic production. This will tend to raise wages by 0.04% causing a negative feedback mechanism which will cause electricity employment income to decrease by 3.9% due to less employment in electricity. Total labor demand will increase by 1.18% due to increase in domestic production resulted from improvement in TFP. Total employment income is affected by changes in wages and labor demand. labor demand will increase by 1.18%, real wages will increase by 0.04% and the net effect is an increase in total employment income by 1.31%.

In scenario 2, an increase in excise tax on imports will cause domestic electricity prices to increase, which will make domestic production and then labor demand to decrease.. On the other hand, labor becomes more expensive relative to capital as real wages increase and price of capital decrease. This will have an inverse effect on demand for labor, net effect on demand for labor will be negative, labor demand will decrease by 10.17%.

Under scenario 3 when both total factor productivity and excise tax on imports change, the effect on the labor demand and labor income is the same as in scenario 2, but it is lower. Labor demand will decrease by 9.13% as price for capital decreases by 0.52%. This decrease in labor demand will result in a reduction in total labor income by 8.9%. The effect on wages is the same but it is larger. In fact, wages will increase by 0.07%.

If the government combines scenario 3 with a subsidy to 15%, the results will vary based on the value of the subsidy. Table 8 shows how total employment changes under different levels of subsidies. A 5% increase in subsidies is not enough to raise total employment. But as the level of subsides increase, the level of employment will also increase, since subsidies for firms lower the cost of production. If subsidies increased by 10%, then total employment will increase by about 1%. And if subsidies increase by 15% then total employment will increase by 4.19%. Increases in total employment lead to an increase in labor demand by 1.88% and 5.78% if subsidies are raised by 10% and 15%, respectively. The increase in labor demand lowers wages by 0.29% when subsidies increase by 10% and 0.49% when subsidies increase by 15%.

Table 8: Changes in Total Employment for Different Changes in Subsidies

Subsidy (%)	5	10	15
Total employment	-2.12	0.94	4.19
Wages	-0.1	-0.29	-0.49
Labor demand	-1.79	1.88	5.78

Households' income

Changes in income for total employment and wages directly affect households' total income. If TFP increases by 10%, then employment income will increase by 1.31% and wages will increase by 0.04%, and as a result total households' income will increase by 0.36%. In scenarios 2 and 3, however, the results are different. The results show that wages will increase but employment income will decrease with negative net effect on households' total income. In the scenario 2, total income will decrease by 0.74%, While in the scenario 3, total income will decrease by 0.4% .

But if the government increases subsidies, then employment income will increase, leading total income to increase as shown in table 9. In fact, total income will increase by 0.06%, 0.48% and 0.93% if subsidies increase by 5%, 10% and 15%, respectively.

Table 9: Results of Changes in Income for Different Changes in Subsidies

Subsidy (%)	5	10	15
Households' total income	0.06	0.48	0.93

6.2 The Analysis of Adding a New Sector (The Second Approach)

The original PalMod model contained 16 sectors, one of which was electricity from traditional sources. We modify this model by adding a new sector; namely, the production of electricity from renewable sources. The solar energy sector is added to both commodities and activities accounts in the 2011 SAM. Solar energy is used in Palestine, but to a very limited scale; the value of its production and the values of transactions between this sector and other sectors are not available[47]. Therefore, the value of electricity generated from solar energy was estimated to be about $0.2 million. The SAM was modified as follows:

1- A new sector was added to both commodities and activities accounts.

2- Then the value of the transactions between this sector and other sectors was estimated in a manner that keeps the SAM in equilibrium. The total electricity production from solar energy is assumed to be $0.2 million; this is reflected in the SAM as the transaction between the electricity sector as a commodity and the solar sector as a production activity. The total production is split into three main values, intermediate input's cost, wages of labor and rental of capital. The value of intermediate inputs is the value of intermediate input from the solar sector used by the electricity sector which is assumed to be $0.02 million. The value of wages of labor is assumed to be $0.06 million, while the value of rents of capital is assumed to be $0.12 million. Rents are greater than wages because this sector is assumed to depend on capital more than labor (capital intensive). Then, wages and rents are transformed into households' income generated from capital ($0.12 million) and from labor ($0.06 million). This income is spent on electricity consumption; the value of this consumption is the total additional income ($0.18 million). Total domestic

[47] There is no data available neither from PCBS nor from PEA. Even that the model assumes the production from solar energy is by firms (not households), electricity produced from solar energy was estimated from what households produced in 2013. It is mentioned (in chapter 3) that by 2013 only 150 households use the photo-voltaic solar arrays. The value of this production was estimated as the following: number of households*expected annual electricity production from arrays*price of kw.

supply of electricity production is the sum of both solar and traditional production.

We first run the model and solve it for the benchmark before adding the new sector (zeros for sector 17) and no adjustments to the import equation. This benchmark is then compared to the simulation when electricity is modeled as a residual between market demand and domestic supply. This means that results obtained from running the model when sector 17 is added with zero values initially is just a replication of results obtained when there are only 16 sectors. Full details about each situation are explained in the following sections.

6.2.1 Scenario 1: An Increase of Solar Energy Production by 10%

The benchmark scenario is to add sector 17 with zero values implying the sector basically does not interact with other sectors of the economy. As discussed earlier, this gives the benchmark with 16 sectors[48]. The results are shown in the second column of Table 10 which gives percentage changes from the first column; the changes are very close to zero. Then, we modify the SAM and change the values of the new sector as outlined above;, the results are shown in the third column of Table 10. Since changes are in the SAM, not a shock in the model, the generated equilibrium could be considered as a new benchmark. Comparing this benchmark with the original one, yields small changes, since the value of the estimated domestic electricity production from solar energy is very small compared to other values in the SAM. The last column in Table 10 shows the results obtained when assuming an increase of 10% in the previously assumed domestic production (current situation). Changes are still very small since 10% from 0.2 is very small.

[48] Modification of a SAM and considering the resulted one to be the benchmark matrix at which all other shocks are compared with it is feasible as used by Missaglia and Boer (2004).

Table 10: The Effect of Adding Solar Energy Sector and an Increase of Domestic Production by 10%[49]

Variable	Benchmark: zero values ($million)	Benchmark: current values (%)	Domestic production (increase by 10%)
Total government revenues	2976.87	0.0000019	0.00023
Total government expenditures	3665.99	0.000000014	0.00019
Total tax revenues	2117.49	0.0000026	0.00033
Governemnt deficit	689.12	0	-0.00002
Electricity imports from Israel	425.57	-0.000004	-0.00027
Domestic production of electricity	292.37	-0.0000006	-0.001
Labor demand for electrcity	23.21	-0.000003	-0.006
Wages	1	-0.000017	0.000009
Unemployment	26.80%	-0.0000031	-0.00062
Households total income	8783.7	-0.0000055	0.00026

Public Finance[50]

Under the current situation ($0.2 million: domestic electricity production from solar energy), and assuming an increase of this domestic production by 10%, government revenues will increase due to the increase in total tax revenues resulting from the increase in labor and capital demand. Under the current situation, it is assumed that the increase in domestic production is combined with an increase in labor and capital demand in the new sector; this in turn increases total labor and capital demand which will cause tax revenues to increase. Government expenditure increases under the current scenario, and is expected to increase if the domestic production increased by 10%. This increase is due to the decrease in prices which causes government consumption to increase which leads government total expenditure to increase. As for government budget deficit, it will not change under the current scenario while it will decrease if domestic production increases since increase in government revenues exceeds the increase in government expenditure.

[49] The benchmark values are measured in $million, except for prices and wages which are normalized to equal 1 in the model, and unemployment level which is measured in percentages.

[50] Here, we only talk about if changes are negative or positive since the values of changes are very small.

External trade

As domestic electricity production increases, supply of electricity will increase which will make electricity imports to decrease, as shown in Table 10 for the bench mark and scenario 1. In Table 10, the row which refers to domestic electricity production is the domestic production from black energy. This value will decrease, because of the increase in production from solar energy. Domestic supply of electricity, however, comes from two sectors: black and solar energy sectors. While the supply of solar energy increases, the supply from black energy decreases, but the total effect is an overall increase in domestic production which leads to a decrease in imports.

Labor market

In our model, there is no data about the number of employees in each sector. Data available is on what labors receive from each sector which is used as an indicator for labor demand. Given that labor supply is constant, then unemployment level is measured as $1 - (labor\ demand/labor\ supply)$. Under the current situation, labor demanded in the electricity sector, real wages and unemployment will decrease. The decrease in labor demand in the electricity sector is due to the decrease in electricity sector production (black energy). Labor demand, however, will increase in solar energy sector due to the increase in this sector production leading total unemployment to decrease. The decrease in labor demand leads to lower average wages due to lower production. Nevertheless, when domestic production increases by 10 % only wages will increase due to decrease in price level, labor demand in electricity sector and unemployment will decrease due to same reasons mentioned before. Increase in domestic production will cause real wages to increase.

Households' income

Wages are one of the main factors affecting households' total income which decreases due to the decrease in real wages under the current situation without assuming an increase in domestic electricity production from solar energy. On the other hand, income will increase due to the increase in wages when assuming an increase in domestic electricity production from solar energy by 10%.

6.2.2 Scenario 2: An Increase of Solar Energy Production by 200%

In this scenario, electricity imports are assumed to be a residual value between domestic demand and supply, and the model is modified according to this assumption. The following equation is added to the model:

$$M(electricty) = D(electricty) - [S(black\ energy) + S(solar\ energy)] \qquad (78)$$

Total electricity imports equals to domestic demand for electricity minus the domestic supply of electricity, from the two sources (black and solar energy). The second column in Table 11 shows results obtained from running the model with this modification and assuming that the domestic production from sector 17 is $0.2 million. This shock is also assumed to be another benchmark at which the following changes are compared to.

Scenario 1 is replicated here but with the new modification; results are almost the same. Therefore, the discussion will concentrate on the new scenario which assumes an increase of domestic production generated from solar energy by 200%,.This high percentage makes the domestic production to be $40 million which is almost about (10% of total electricity consumption) which matches the goals of the ‘renewable energy strategy’ launched by PEA.

Public Finance

When domestic electricity production from solar energy increases to a level of $40 million, then government total revenue will increase by 0.437% due to the increase in total tax revenues by 0.614% which results from the increase in total labor demand (as shown in the last column from Table 11, unemployment will decrease). Government expenditure will also increase by 0.355% due to increase in government total consumption resulted from the decrease in prices. Government budget deficit will decrease by 0.0008% (almost not affected, it will decrease by $60 thousands)). The most important result concluded, from this scenario, is that implementing a solar energy program in Palestine will not have a negative effect on government budget.

Table 11: Results Obtained Assuming that Imports are Determined Residually

Variable	Benchmark(17 sectors) (%)	Domestic production (increase by 10%) (%)	Domestic production (increase by 200%) (%)
Total government revenues	0.000011	0.00023	0.437
Total government expenditures	0.000007	0.00019	0.355
Total tax revenues	0.000015	0.00033	0.614
Governemnt deficit	0	-0.0002	-0.0008
Electricity imports from Israel	-0.000014	-0.00027	-0.467
Domestic production of electricity	-0.000044	-0.001	-2.285
Labor demand for electrcity	-0.00024	-0.006	-10.584
Wages	0.000011	0.00001	0.028
Unemployment	-0.00012	-0.00062	-1.107
Households total income	-0.000014	0.00026	0.505

External trade

When analyzing the impact on external trade, it must be taken into account that electricity imports equal to the difference between demand and supply. If domestic production increases, then imports will decrease by 0.467%. Moreover, domestic electricity production from black energy will decrease by 2.285%, which means that solar energy production of electricity is a substitute for both electricity imports and domestic production from black energy which is reflected in the new equation, which is added in the second scenario of the second approach.

Labor market

Labor demand in the electricity sector will decrease by 10.584%. This large effect results from the decrease in the domestic production of the traditional electricity production sector (2.285%) and the decrease in the price of capital by about 40%. Notice that electricity sector uses capital more than labor (capital to labor ratio is about 4:1), which means that for any small decrease in price of capital, demand for capital will increase at the expense of labor demand as they are substitutes. Real wages will increase by 0.028% due to the increase in labor demand and the decrease in prices. Unemployment will also decrease by 1.107% due to increase in labor demand on the new sector and other sectors despite of the sharp decrease in labor demand for electricity sector. This is explained by the fact that labor demand for electricity sector is 0.7% from total labor demand only.

Households' income

Household's total income is positively affected by the increase in domestic electricity production from solar energy. As wages increase, total households income will also increase. The increase in wages causes income to increase by 0.505% as shown in Table 11.

Chapter 7: Conclusions and Recommendations

This research investigates the economic impact of increased solar energy production in Palestine. In particular, the study shows how the increased solar energy production replaces production using fossil fuels and its impact on public finance, external trade labor market, and households' total income. The analysis uses a computable general equilibrium model for Palestine which is based on the 2011 SAM and is calculated using GAMS software. The impact was measured under two main approaches: the first, simulates changes in the traditional electricity sector, and the second adds the solar energy sector to the SAM. Under the first approach, three different scenarios were assumed. Scenario 1 assumes an increase of total factor productivity in the electric sector by 10% which reflects solar energy technology's effect on cost. Scenario 2 assumes an increase of excise tax on electricity imports by 10%. And scenario 3 assumes an increase of both total factor productivity as an indicator of increase in domestic electricity production, and excise taxes as a government intervention to decrease the level of imports. Under approach 2, two main scenarios were assumed, the first alters the SAM only, and then the model was shocked by a 10% increase in domestic electricity production from solar energy. The second alters the SAM and equations, then the model was also shocked by an increase in domestic electricity production from solar energy.

Under the first approach results show that solar energy program will benefit the Palestinian government. Government budget deficit will decrease in all scenarios. It will decrease by 0.09% ($0.62 million) in scenario 1, 0.23% ($1.58 million) in scenario 2 and 0.138% ($0.95 million) in scenario 3. Domestic production will also increase in scenario1 by 9.16% ($26.7 million) and in scenario 3 by 8.9% ($26 million); however, it will decrease in scenario 2 by 0.17% ($0.5). Electricity imports from Israel will increase by 0.76% ($3.23 million) in scenario 1 due to the increase in domestic demand and the increase in income. In scenario 2, however, it will decrease by 6.07% ($25.8 million) and in scenario 3 by 5.37% ($22.8 million) as a result of the increase in excise tax on electricity imports. Labor demand will increase by 1.18% in scenario 1, if total factor productivity increases, while it will decrease in scenarios2 and 3 by 10.17% and 9.13%, respectively. The results also show that if the government subsidizes the electricity production sector by 10%, then labor demand will increase by 1.88%. On the other hand, labor demand will increase by 5.78% if subsidies increase by 15%. Finally, households total income will increase in scenario 1 by 0.36% ($ 31.6 million), while it will decrease in scenario 2 by 0.74% ($65 million) and by 0.4% ($ 35 million) in scenario 3 due to the decrease in total employment. However, if government subsidies increase by 10%, then total employment will increase by 1% causing total households' income to increase by about 0.5% ($ 42 million).

Under scenario 1 of the second approach, altering the SAM initially with no changes (or shocks) gives the same results as the first approach. When the value of production from solar energy sector is estimated to be $0.2 million, followed by a 10% increase in production, then there will be a positive but limited effects on public finance, external trade, labor market and households' income. Under scenario 2 where electricity imports were determined residually as the difference between demand and supply, an increase of domestic production by 200% will have a positive effect on the economy. The most important results were, a decrease in budget deficit by 0.0008% ($60 thousands), a decrease in electricity imports from Israel by 0.467% ($1.99 million), a decrease in unemployment level by 1.107% and a increase in households total income by 0.505% ($44 million).

Solar energy has a positive effect on all sections of the economy. It is positively affects government budget, external trade, labor market and households. Households and firms must tap into this idea since there will be income gains that were measured here. But the long run[51] gains, which are not measured here, are expected to be larger because the cost of arrays is expected to decrease. Households' investment in the program is not enough. For this program to succeed, the Palestinian government should give subsidies, since this subsidy[52] is feasible. For example, the government might allocate a portion of foreign aid to the solar energy program. If the Palestinian government can't bear the cost of implementing this renewable energy program through subsidies, then the government is expected to encourage individuals, private sector, NGOs, foreign funders or donors to cooperate in renewable energy projects. If it is expected to produce about 10% of total electricity consumption using solar arrays system by 2020, then about 30,000 households are expected to install solar arrays. They are expected to pay about $190 million[53]. Then PA is expected to give a subsidy of about 10%of the total cost ($190 mil) to all 30,000 households (through foreign aid or redistribution of government expenditure) to achieve the previously mentioned positive effects. The cost of this initiative is very small compared to big item tickets on the government's budget and it is not reoccurring.

More advanced studies are still needed. Those studies must cover the limitations of this study. A more advanced study may use a recent SAM, dynamic CGE model, take into account impact on environment or it might add banks as institutions and measure the effect of easy loans to households in order to install arrays.

[51] In this thesis static CGE model was used, which analyzes an economy at a given period of time. Dynamic CGE model takes into account the change in time, and measures what will happen after a specific period of time.
[52] In this model, results were measured for changes in subsidies for the electricity production sector not to households. But as the solar energy program needs households to generate electricity through the photo-voltaic system, then households turn to be the producers.
[53] This figure was calculated based on average household consumption per year which is 260 kw.h

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Appendices

A.1 Optimization of Model Equations

Firms:

Producers minimize their cost function

$$cost_s(K_s, L_s) = PK_s.(1 + tk_s) + d_s.\left(PIT_{s=nsgv} + PITG_{s=sgv}\right)$$

$$.K_s/(1 + trcs_s) + [PL.(1 + tl_s)].L_s \qquad \text{(A1)}$$

subject to:

$$KL_s = \alpha F_s.(\gamma FK_s.K_s^{-\rho F_s}/(1 + trcs_s)^{-\rho F_s} + \gamma FL_s.L_s^{-\rho F_s})^{-1/\rho F_s} \qquad \text{(A2)}$$

Lagrangian equation is:

$$\mathcal{L} = \left[PK_s.(1 + tk_s) + d_s.\left(PIT_{s=nsgv} + PITG_{s=sgv}\right)\right].$$

$$K_s/(1 + trcs_s) + [PL.(1 + tl_s)].L_s +$$

$$\lambda[KL_s - \alpha F_s.\left(\gamma FK_s.K_s^{-\rho F_s}/(1 + trcs_s)^{-\rho F_s} + \gamma FL_s.L_s^{-\rho F_s}\right)^{-1/\rho F_s}] \qquad \text{(A3)}$$

Let $PC_s = PK_s.(1 + tk_s) + d_s.\left(PIT_{s=nsgv} + PITG_{s=sgv}\right)/(1 + trcs_s)$, then $\mathcal{L} = PC_s.K_s + [PL.(1 + tl_s)].L_s + \lambda[KL_s - \alpha F_s.$

$$\left(\gamma FK_s.K_s^{-\rho F_s}/(1 + trcs_s)^{-\rho F_s} + \gamma FL_s.L_s^{-\rho F_s}\right)^{-1/\rho F_s}] \qquad \text{(A4)}$$

$$\frac{d\,\mathcal{L}}{dK_s} = PC_s - \lambda\alpha F_s.\frac{1}{\rho F_s}.\left(\gamma FK_s.K_s^{-\rho F_s}/(1 + trcs_s)^{-\rho F_s} + \gamma FL_s.L_s^{-\rho F_s}\right)^{-1/\rho F_s - 1}$$

$$.\gamma FK_s.\rho F_s.K_s^{-\rho F_s - 1}.(1/1 + trcs_s)^{-\rho F_s} \qquad \text{(A5)}$$

$$\frac{d\,\mathcal{L}}{dK_s} = PC_s - \lambda\alpha F_s.\left(\gamma FK_s.K_s^{-\rho F_s}/(1 + trcs_s)^{-\rho F_s} + \gamma FL_s.L_s^{-\rho F_s}\right)^{-1/\rho F_s - 1}$$

$$.\gamma FK_s.K_s^{-\rho F_s-1}.(1/1+trcs_s)^{-\rho F_s} \quad \text{(A6)}$$

$$PC_s = \lambda\alpha F_s.\left(\gamma FK_s.K_s^{-\rho F_s}/(1+trcs_s)^{-\rho F_s}+\gamma FL_s.L_s^{-\rho F_s}\right)^{-1/\rho F_s-1}$$

$$.\gamma FK_s.K_s^{-\rho F_s-1}.(1+trcs_s)^{-\rho F_s} \quad \text{(A7)}$$

$$\frac{d\,\mathcal{L}}{dL_s} = PL.(1+tl_s)-\lambda\alpha F_s.\frac{1}{\rho F_s}.$$

$$\left(\gamma FK_s.K_s^{-\rho F_s}/(1+trcs_s)^{-\rho F_s}+\gamma FL_s.L_s^{-\rho F_s}\right)^{-1/\rho F_s-1}$$

$$.\gamma FL_s.\rho F_s.L_s^{-\rho F_s-1}=0 \quad \text{(A8)}$$

$$\frac{d\,\mathcal{L}}{dL_s} = PL.(1+tl_s)-\lambda\alpha F_s.\left(\gamma FK_s.K_s^{-\rho F_s}/(1+trcs_s)^{-\rho F_s}+\gamma FL_s.L_s^{-\rho F_s}\right)^{-1/\rho F_s-1}$$

$$.\gamma FL_s.L_s^{-\rho F_s-1}=0 \quad \text{(A9)}$$

$$PL.(1+tl_s) = \lambda\alpha F_s.\left(\gamma FK_s.K_s^{-\rho F_s}/(1+trcs_s)^{-\rho F_s}+\gamma FL_s.L_s^{-\rho F_s}\right)^{-1/\rho F_s-1}$$
$$.\gamma FL_s.L_s^{-\rho F_s-1} \quad \text{(A10)}$$

$$\frac{d\,\mathcal{L}}{d\lambda} = KL_s-\alpha F_s.\left(\gamma FK_s.K_s^{-\rho F_s}/(1+trcs_s)^{-\rho F_s}+\gamma FL_s.L_s^{-\rho F_s}\right)^{-1/\rho F_s}=0 \quad \text{(A11)}$$

$$KL_s = \alpha F_s.\left(\gamma FK_s.K_s^{-\rho F_s}/(1+trcs_s)^{-\rho F_s}+\gamma FL_s.L_s^{-\rho F_s}\right)^{-1/\rho F_s} \quad \text{(A12)}$$

Dividing (A10) by (A7) results in:

$$\frac{PL.(1+tl_s)}{PC_s} = \frac{\gamma FL_s.L_s^{-\rho F_s-1}}{\gamma FK_s.K_s^{-\rho F_s-1}}.(1+trcs_s)^{-\rho F_s} \quad \text{(A13)}$$

$$L_s = \left(\frac{PL.(1+tl_s)}{PC_s}.\frac{\gamma FL_s}{\gamma FK_s}.(1+trcs_s)^{\rho F_s}\right)^{-1/1+\rho F_s}.K_s \quad \text{(A14)}$$

Substitution of (A14) in (A12) yields

$$KL_s = \alpha F_s.(\gamma FK_s.K_s^{-\rho F_s}/(1+trcs_s)^{-\rho F_s} + \gamma FL_s$$

$$.[(\frac{PL.(1+tl_s)}{PC_s}.\frac{\gamma FL_s}{\gamma FK_s}.(\frac{1}{1+trcs_s})^{-\rho F_s})^{-1/1+\rho F_s}.K_s]^{-\rho F_s})^{-1/\rho F_s} \quad \text{(A15)}$$

$$KL_s = \alpha F_s.(\gamma FK_s/(1+trcs_s)^{-\rho F_s} + \gamma FL_s$$

$$.[(\frac{PL.(1+tl_s)}{PC_s}.\frac{\gamma FL_s}{\gamma FK_s}.(\frac{1}{1+trcs_s})^{-\rho F_s})^{-1/1+\rho F_s}]^{-\rho F_s})^{-1/\rho F_s}.K_s \quad \text{(A16)}$$

Given that:

$\sigma F_s = \frac{1}{1+\rho F_s}$, $1-\sigma F_s = \frac{\rho F_s}{1+\rho F_s}$, and $\frac{1}{\rho F_s} = \frac{1-\sigma F_s}{\sigma F_s}$, then

$$K_s = (KL_s/\alpha F_s).[\gamma FK_s/(1+trcs_s)^{-\rho F_s} + \gamma FL_s$$

$$(\frac{PL.(1+tl_s)}{PC_s}.\frac{\gamma FL_s}{\gamma FK_s}.(\frac{1}{1+trcs_s})^{-\rho F_s})^{1-\sigma F_s}]^{\sigma F_s/1-\sigma F_s} \quad \text{(A17)}$$

Now take$(\frac{\gamma FK_s}{PC_s})^{1-\sigma F_s}$ as a common factor, then

$$K_s = (KL_s/\alpha F_s).(\gamma FK_s/PC_s.(1+trcs_s)^{-\rho F_s})^{\sigma F_s}.(\gamma {FK_s}^{\sigma F_s}.{PC_s}^{1-\sigma F_s} + \gamma {FL_s}^{\sigma F_s}.\left(PL.(1+tl_s)\right)^{1-\sigma F_s}.(\frac{1}{1+trcs_s})^{-\rho F_s}]^{\sigma F_s/1-\sigma F_s} \quad \text{(A18)}$$

Now substitute the value of PC_s in the previous equation and take $1/1+trcs_s$ as a common factor:

$$K_s = (KL_s.(1+trcs_s)/\alpha F_s).\left(\gamma FK_s/\begin{matrix}[PK_s.(1+tk_s)+d_s. \\ (PIT_{s=nsgv}+PITG_{s=sgv})]\end{matrix}\right)^{\sigma F_s}.$$

$$.[\gamma {FK_s}^{\sigma F_s}.(PK_s.(1+tk_s)+d_s.\left(PIT_{s=nsgv}+PITG_{s=sgv}\right))^{1-\sigma F_s} + \gamma {FL_s}^{\sigma F_s}.(PL.(1+tl_s))^{1-\sigma F_s}]^{\sigma F_s/1-\sigma F_s} \quad \text{(A19)}$$

Substitution of K_s in the equation of L_s yields:

$$L_s = \left(\frac{PL.(1+tl_s).(1+trcs_s)}{PK_s.(1+tk_s)+d_s.\left(PIT_{s=nsgv}+PITG_{s=sgv}\right)}.\frac{\gamma FL_s}{\gamma FK_s}.(1 + trcs_s)^{\rho F_s}\right)^{-1/1+\rho F_s}$$

$$.(KL_s.(1+trcs_s)/\alpha F_s).\left(\gamma FK_s/\begin{matrix}[PK_s.(1+tk_s)+d_s.\\ \left(PIT_{s=nsgv}+PITG_{s=sgv}\right)]\end{matrix}\right)^{\sigma F_s}$$

$$.[\gamma FK_s{}^{\sigma F_s}.(\,PK_s.(1+tk_s)+d_s.\left(PIT_{s=nsgv}+PITG_{s=sgv}\right))^{1-\sigma F_s}$$

$$+\gamma FL_s{}^{\sigma F_s}.(PL.(1+tl_s))^{1-\sigma F_s}]^{\sigma F_s/1-\sigma F_s} \qquad \text{(A20)}$$

$$L_s = \left(\frac{PL.(1+tl_s).(1+trcs_s)}{PK_s.(1+tk_s)+d_s.\left(PIT_{s=nsgv}+PITG_{s=sgv}\right)}.\frac{\gamma FL_s}{\gamma FK_s}(1 + trcs_s)^{(1-\sigma F_s)/\sigma F_s}\right)^{-\sigma F_s}$$

$$.(KL_s.(1+trcs_s)/\alpha F_s).\left(\gamma FK_s/\begin{matrix}[PK_s.(1+tk_s)+d_s.\\ \left(PIT_{s=nsgv}+PITG_{s=sgv}\right)]\end{matrix}\right)^{\sigma F_s}$$

$$.[\gamma FK_s{}^{\sigma F_s}.(\,PK_s.(1+tk_s)+d_s.\left(PIT_{s=nsgv}+PITG_{s=sgv}\right))^{1-\sigma F_s}$$

$$+\gamma FL_s{}^{\sigma F_s}.(PL.(1+tl_s))^{1-\sigma F_s}]^{\sigma F_s/1-\sigma F_s} \qquad \text{(A21)}$$

$$L_s = \left(\frac{PL.(1+tl_s)}{PK_s.(1+tk_s)+d_s.\left(PIT_{s=nsgv}+PITG_{s=sgv}\right)}.\frac{\gamma FL_s}{\gamma FK_s}(1 + trcs_s)^{1/\sigma F_s}\right)^{-\sigma F_s}$$

$$.(KL_s.(1+trcs_s)/\alpha F_s).\left(\gamma FK_s/\begin{matrix}[PK_s.(1+tk_s)+d_s.\\ \left(PIT_{s=nsgv}+PITG_{s=sgv}\right)]\end{matrix}\right)^{\sigma F_s}$$

$$.[\gamma FK_s{}^{\sigma F_s}.(\,PK_s.(1+tk_s)+d_s.\left(PIT_{s=nsgv}+PITG_{s=sgv}\right))^{1-\sigma F_s}$$

$$+\gamma FL_s{}^{\sigma F_s}.(PL.(1+tl_s))^{1-\sigma F_s}]^{\sigma F_s/1-\sigma F_s} \qquad \text{(A22)}$$

Rewrite the previous equation, then L_s will be:

$$L_s = (KL_s/\alpha F_s).[\gamma FL_s/(1+tl_s)]^{\sigma F_s}.[\gamma FK_s^{\sigma F_s}.((1+tk_s).PK_s + d_s$$

$$.\left(PIT_{s=nsgv} + PITG_{s=sgv}\right))^{1-\sigma F_s} + \gamma FL_s^{\sigma F_s}.\left((1+tl_s).PL\right)^{1-\sigma F_s}]^{(\sigma F_s/(1-\sigma F_s))} \quad \text{(A23)}$$

Households:

Maximize $U(C_c) = \prod_c (C_c - \mu H_c)^{\alpha H_c}$ subject to budget constraint:

$$CBUD = \sum_c (1 + tvat_c + texc_c + tc_c - tsc_c).P_c.(1 + trcc_c).C_c) \quad \text{(A24)}$$

$$\mathcal{L} = \prod_c (C_c - \mu H_c)^{\alpha H_c} + \lambda[CBUD - \sum_c (1 + tvat_c + texc_c + tc_c - tsc_c).P_c.(1 + trccc.Cc)\ ] \quad \text{(A25)}$$

$$\frac{d\,\mathcal{L}}{d\lambda} = \alpha H_c (C_c - \mu H_c)^{\alpha H_c - 1}.\prod_{\grave{c}\neq c} (C_{\grave{c}} - \mu H_{\grave{c}})^{\alpha H_{\grave{c}}} - \lambda(1 + tvat_c + texc_c + tc_c - tscc.Pc.1+trccc=0 \quad \text{(A26)}$$

There will be c equations of $\frac{d\,\mathcal{L}}{dC_c}$.

$$\frac{d\,\mathcal{L}}{d\lambda} = CBUD - \sum_c (1 + tvat_c + texc_c + tc_c - tsc_c).P_c.(1 + trcc_c).C_c) = 0 \quad \text{(A27)}$$

Rest of the world:

Import side[54]:

Minimize $cost_c(XDD_c, M_c) = PDD_c.XDD_c + PM_c.M_c$ subject to :

$$X_c = (\alpha A_c/(1 + trcc_c)).((1 - \gamma A_c).XDD_c^{-\rho A_c} + \gamma A_c.M_c^{-\rho A_c})^{-1/\rho A_c} \quad \text{(A28)}$$

$\mathcal{L} = PDD_c.XDD_c + PM_c.M_c + \lambda[X_c -$

[54] Same derivation holds for import from Israel and import from ROW, and for the export side.

$$(\alpha A_c/(1+trcc_c)).((1-\gamma A_c).XDD_c^{-\rho A_c}+\gamma A_c.M_c^{-\rho A_c})^{-1/\rho A_c}] \quad \text{(A29)}$$

$$\frac{d\,\mathcal{L}}{dXDD_c} = PDD_c - \lambda.(\alpha A_c/(1+trcc_c)).(1/\rho A_c).((1-\gamma A_c).XDD_c^{-\rho A_c} + \gamma A_c.M_c^{-\rho A_c})^{-1/\rho A_c - 1}.(1-\gamma A_c).\rho A_c.XDD_c^{-\rho A_c - 1} \quad \text{(A30)}$$

$$\frac{d\,\mathcal{L}}{dM_c} = PM_c - \lambda.(\alpha A_c/(1+trcc_c)).(1/\rho A_c).\left((1-\gamma A_c).XDD_c^{-\rho A_c} + \gamma A_c.M_c^{-\rho A_c}\right)^{-1/\rho A_c - 1}.(\gamma A_c).\rho A_c.M_c^{-\rho A_c - 1} = 0 \quad \text{(A31)}$$

$$\frac{d\,\mathcal{L}}{d\lambda} = X_c - (\alpha A_c/(1+trcc_c)).((1-\gamma A_c).XDD_c^{-\rho A_c}+\gamma A_c.M_c^{-\rho A_c})^{-1/\rho A_c} = 0 \quad \text{(A32)}$$

When divide (A30) by (A31), then we obtain:

$$\frac{PDD_c}{PM_c} = \frac{(1-\gamma A_c)}{\gamma A_c}.(\frac{XDD_c}{M_c})^{-(\rho A_c+1)} \quad \text{(A33)}$$

$$XDD_c = (\frac{PDD_c}{PM_c}.\frac{\gamma A_c}{1-\gamma A_c})^{-1/(\rho A_c+1)}.M_c \quad \text{(A34)}$$

Substitution of (A34) in equation (A32) gives:

$$X_c = (\alpha A_c/(1+trcc_c)).[(1-\gamma A_c).\left(\left(\frac{PDD_c}{PM_c}.\frac{\gamma A_c}{1-\gamma A_c}\right)^{-1/(\rho A_c+1)}.M_c\right)^{-\rho A_c} + \gamma A_c.M_c^{-\rho A_c}]^{-1/\rho A_c} \quad \text{(A35)}$$

Given that $\sigma A_c = \frac{1}{1+\rho A_c}$, then

$$M_c = (X_c/\alpha A_c/(1+trcc_c)).[(1-\gamma A_c).\left(\frac{PDD_c}{PM_c}.\frac{\gamma A_c}{1-\gamma A_c}\right)^{1-\sigma A_c} + \gamma A_c]^{(1-\sigma A_c)/\sigma A_c} \quad \text{(A36)}$$

And XDD_c will be

$$XDD_c = (X_c/\alpha A_c/(1+trcc_c)).[(1-\gamma A_c) + \gamma A_c.\left(\frac{PDD_c}{PM_c}.\frac{\gamma A_c}{1-\gamma A_c}\right)^{\sigma A_c - 1}]^{(1-\sigma A_c)/\sigma A_c} \quad \text{(A37)}$$

Given that the formula of the composite price P_c is :

$$P_c = [(1 + trcc_c)(\gamma A_c{}^{\sigma A_c} . \left(\frac{PM_c}{\alpha A_c}\right)^{1-\sigma A_c} + (1 - \gamma A_c)^{\sigma A_c} . \left(\frac{PDD_c}{\alpha A_c}\right)^{1-\sigma A_c})]^{1/(1-\sigma A_c)} \quad \text{(A38)}$$

Divide the previous equation by PM_c and PDD_c respectively then:

$$(\frac{P_c}{PM_c})^{1-\sigma A_c} = (1 + trcc_c)(\gamma A_c{}^{\sigma A_c} . \left(\frac{1}{\alpha A_c}\right)^{1-\sigma A_c} + (1 - \gamma A_c)^{\sigma A_c} . \left(\frac{PDD_c}{\alpha A_c . PM_c}\right)^{1-\sigma A_c}) \quad \text{(A39)}$$

$$(\frac{P_c}{PDD_c})^{1-\sigma A_c} = (1 + trcc_c)(\gamma A_c{}^{\sigma A_c} . \left(\frac{PM_c}{\alpha A_c . PDD_c}\right)^{1-\sigma A_c} + (1 - \gamma A_c)^{\sigma A_c} . \left(\frac{1}{\alpha A_c}\right)^{1-\sigma A_c}) \quad \text{(A40)}$$

Then M_c and XDD_c will be:

$$M_c = X_c . (1 + trcc_c) . (P_c / PM_c)^{\sigma A_c} . \gamma A_c^{\sigma A_c} . \alpha A_c^{\sigma A_c - 1} \quad \text{(A41)}$$

$$XDD_c = X_c . (1 + trcc_c) . (P_c / PDD_c)^{\sigma A_c} . (1 - \gamma A_c)^{\sigma A_c} . \alpha A_c^{\sigma A_c - 1} \quad \text{(A42)}$$

A.2 List of Variables

Appendix B shows lists of exogenous and endogenous variables used in PalMod model.

A.2.1 List of endogenous variables

PK_s: Return to capital

PL: Price of labor ‘wage rate’

P_c: Price of composite commodity c

PD_s: Domestic prices of commodities

PDD_c: Price of domestic commodities domestically supplied

$PDDE_c$: Price of domestic commodities that are supplied to domestic and foreign markets

PE_c: Price of exports in national currency

PM_c: Price of imports in national currency

ER: Exchange rate

$PCINDEX$: Consumer price index

X_c: Composite commodities

XD_s: Domestic production of activity s

E_c: Export

M_c: Import

XDD_c: Domestic commodities domestically supplied

$XDDE_c$: Domestic commodities supplied to domestic and foreign markets

$PMISR_c$: Price from imports from Israel

$PMROW_c$: Price of imports from rest of the world

$MISR_c$: Imports from Israel

$MROW_c$: Imports from rest of the world

PWE_c: Price of exports in national currency

PWM_c: Price of imports in national currency

$PEISR_c$: Price from exports from Israel

$PEROW_c$: Price of exports from rest of the world

$EISR_c$: Exports to Israel

$EROW_c$: Exports to rest of the world

PKL_s: Value added price index

KL_s: Value added, labor-capital mix

K_s: Capital demand

L_s: Labor demand

C_s: Commodities demand

$CBUD$: Disposable income

$UNEMP$: Number of unemployed

YH: Household income

SH: Household savings

S: Total savings

I_c: Private investment for commodities

IG_c: Public investment for commodities

$shINV_s$: Shares of private investment by branch of activities

$INVPv_s$: Values of private investment by branch of activity

$INVPb_s$: Values of public investment by branch of activity

ITT: Real total private investment

$ITTN$: Nominal total private investment

PIT: Price of investment in the private sector

$PITG$: Price of investment in the public sector

$IGTN$: Total public investment

CG_c: Public demand for commodities

$CGBUD$: Public final consumption expenditure

GDP: Nominal gross domestic product (at constant market price)

$GDPC$: GDP at current market prices

$GDPDEF$: GDP deflator

$rCGBUDGDP$: Ratio of government final consumption expenditure to GDP

$rSGBALGDP$: Ratio of government savings to GDP

$GREV$: Government revenues

$GEXP$: Government expenditures

$TAXR$: Total tax revenues

TRF: Transfers to households

SV_c: Variation of stocks

A.2.2 List of exogenous variables

KS: Capital supply

LS: Labor supply

$PWMISR_c$: World price of imports from Israel in local currency

$PWMROW_c$: World price of imports from rest of the world in local currency

$SWISR$: Savings from Israel

$SWROW$: Savings from rest of the world

YLW: Labor income from Israel

$SGBAL$: Government budget

$TRHG$: Government transfers to households

$TRGROW$: Transfers to government from rest of the world

IGT: Capital formation by government

tl_s: Labor tax rate

tk_s:Capital tax rate

$tvat_c$: VAT on consumption

tm_c: Customs rate on consumption

$texc_c$: Excise rate on consumption

tc_c: Other taxes on consumption

$tvatf_c$: VAT on imports

tmf_c: Customs rate on imports

$texcf_c$: Excises rate on imports

tcf_c: Other taxes on imports

$tpurf_c$: Purchase tax on imports

tsc_c: Subsides rate

ty: Income tax on revenues from Palestine

tyf: Income tax on revenues from abroad

μH_c: Subsistence level of consumption