Estimating the Impact of Environmental Policies on Trade and Competitiveness; Evidence from the Gaza Strip

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ABSTRACT: *Theories of international trade support the assumption that relatively strict environmental policies can have a strong impact on production and foreign trade. Nevertheless, empirical studies present mixed results. This paper links two previous econometric approaches of environmental-policy-trade relationship, namely Larson (2000) and Jaffe et al. (2002). The Larson approach involves a partial equilibrium model that estimates the percentage change in output, exports and/or imports due to some changes in production costs caused by complying with a higher environmental standard. The Jaffe et al. (2002) approach however, suggests that market-based instruments create more efficient incentives for firms to comply with the environmental policies than command-and-control policies and introducing uncertainty and statistical errors to the compliance costs. The application of the Larson model requires that the compliance cost of the proposed environmental standard to be known constant. In this paper, a statistical model has been developed by incorporating those principles of Jaffe et al. (2002) in the Larson model at the sector level. The Larson model was applied to conduct at firm level analysis of trade and environmental linkages in reference to proposed environmental standards or a generic increase in the firm's production costs. Using the modified model, we compare the effects of direct regulations and of adoption of subsidies at the sector level assuming uncertainty in the firms' compliance costs. The aim of this is to study the impact of environmental policies that will be considered for adoption by the Palestinian National Authority on trade and production of specific Palestinian economic sectors in the Gaza Strip.*

Key words: equilibrium models, uniform distribution, trade and environment, compliance costs, environmental policies.

INTRODUCTION

Whereas theoretical analyses of trade and environment indicate that relatively strict environmental policies can have a strong impact on production and foreign trade, empirical studies present mixed results. There are quite many empirical studies on the impact of environmental stringency on competitiveness have been performed. Nevertheless, most studies are incomparable to other ones with the consequences that results do not lead to the same conclusion mainly due to differences in model assumptions, methods employed and data used. For instance, the diversity of approaches range between simple statistical indicators (Walter and Ugelow; 1979 and Low and Yeats; 1992) to multivariate regression models (Tobey; 1993) or applied equilibrium modelling (Steininger; 1999 and Jaffe *et al*., 1995), from single country (Low and Yeats; 1992) to multi-country (Xu and Song; 2000), and from the analysis at the firm level (Tobey; 1990) to the sector level (all other studies mentioned above). The differences in study outcomes are mainly related to the type of data used and to different methods employed.

It is often argued that significant reductions in environmental impacts can be achieved through a more widespread adoption of pollution abatement technologies. Many economists believe that incentives is an efficient instrument for pollution regulation for firms to adopt new technologies because it tends to force firms to take similar shares of the pollution control burden, regardless of the cost (Jaffe *et al*., 2002). Policy makers however, consistently give preference to direct regulation. In this paper we develop a model for comparing the effects of a direct technology regulation on the one hand and the effects of an adoption subsidy on the other hand. The model revolves around the policy makers who care about the environment, the financial position of the government and the financial position of the firms. Environmental protection requires that firms adopt a new technology. The policy makers can compel firms adopt this new technology or they can encourage the adoption of the new technology by subsidizing it.

This paper aims at quantifying and measuring the impact of complying with environmental policy measures, being considered for adoption by the Palestinian Environment Quality Assurance Authority (EQA), using different policy instruments, has on production and trade of specific important manufacturing sectors in the Palestinian Authority that produce for exports and may become threatened by imports. The purpose of this analysis is to measure the sensitivity of outputs, exports and imports to production cost changes induced by compliance with adopting a more stringent environmental policy regulation. Therefore, we will first discuss the models used for this purpose then we will apply the results on some of the Palestinian industrial sectors.

The industrial sector in the Palestinian economy is small with a share of the total output varied between 9% and 12% and accounted for 15-20% of the total local employment (PCBS, 2002). The industrial sector however, is looked at as the principal economic sector, with great potential for development of the Palestinian economy as well as having the solution for the unemployment problems through increasing the number and size of the industrial firms and concentrating on the labor intensive industries. At present, the industrial sector is characterized by small, fragmented, traditional and dominated by family owned workshops. Growth of the private sector in Palestine is constrained not only by the lack of natural resources but also by the underdeveloped infrastructure and by the scarcity of land and water resources. The quality of water in the Gaza Governorates is a serious problem caused mainly by the sanitary practices including sewage and solid waste disposals.

Furthermore, the present political situation in Palestine resulted in many major constraints to the industrial sector and to the Palestinian economy as a whole. Those include frequent closure of the Palestinian districts by the Israelis and the absence of Palestinian controlled seaports and airports as well as outlets to the neighbouring countries. This resulted in difficulties to export the industrial products and to import raw materials. The present small size of the industrial sector as a result of the above constraints kept the industrial water demand at its low level. It is expected that the industrial water demand will increase as soon as some of constraints are lifted and the industrial infrastructure improved.

In the next section, we will discuss the model set up. We start by describing the Larson model then we will introduce the possible policy instruments that the Palestinian Authority will most likely adopt. The choices of the environmental policy measures and the selected industries which are used for application are discussed in the subsequent two sections. In later sections, the Larson model at the firm level, and the modified model at the sector level on the three selected industries will be applied.

I. The model:

The aim of this study is to develop a model for quantifying and measuring the impact of complying with environmental policy measures on production and trade of specific Palestinian economic sectors that produce for exports and may become threatened by imports using different policy instruments. The model is built mainly on an economic model that has been developed by Larson (2000) for estimating the impact of a proposed environmental policy on trade and development of a specific firm or a specific economic sector. In order to comply with the proposed policy measures, we assume that each firm would be characterized by a compliance cost which captures the cost of adopting the new environmental standards. The Larson model involves a partial equilibrium model that estimates the percentage change in output and exports due to the cost of compliance with a higher environmental standard and cause some change in the firm's production costs. However the compliance costs should be known in order to efficiently apply the model. At the sector level however, the compliance cost of the whole economic sector could not be known precisely to efficiently apply the Larson model. Therefore, we modify the Larson model in order to take an account of the uncertainty of the firms' decision to comply with the new regulations and the firms' compliance costs. Using the modified model we examine the effects of two instrument choices that allocate risks in different ways for the policy makers to implement the proposed policy, on trade and development at the sector level.

Now, the Larson model involves estimating the effect of the environmental policy on trade at the firm level and can be applied at the sector level provided that the cost of compliance is known. The Larson model is fully described in METAB (2002). In this paper, we utilize the *average cost case* of the Larson model since we assume that the new environmental policy standards would impose additional costs on the firm/sector that are related to the production levels but are not directly related to specific inputs used in the production process. For the sake of completeness, we summarize the average cost case of the Larson model as described in METAB (2002) and using the same notations with slight modifications for clarity as follows:

Y = the level of output,
w = major input prices,
r = other input prices,
C = C(Y,w,r) = the costs of producing *Y* units of output with input prices *w* and *r*,
m = the increase in average costs of production due to the regulation,
p = the unit price of the output, and
pY = revenues earned by selling *Y* units of output for price *p*.

To measure the change compared to the original level of production, it is convenient to discuss such effects in percentage terms, denoted as Δ_{Y_0}, where

$$\Delta_{Y_0} = (Y_1 - Y_0)/Y_0 \qquad (1)$$

is the percentage change in production. For the export sector, the percentage change in output Δ_{Y_0} will be reflected in the percentage change in exports as a share of the initial exports E_0. The percentage change in exports out of the initial exports E_0 is denoted as Δ_{E_0} and can be computed as:

$$\Delta_{E_0} = \Delta_{Y_0} /(E_0 / Y_0) \qquad (2)$$

where the ratio E_0/Y_0 is the initial share of exports to total production.

For the import sector, imports are $I_0 = B_0 - Y_0$ where B_0 is the number of units consumed domestically when Y_0 units are produced, and the remaining amount ($E_0 = Y_0 - B_0$) is exported. In this case, the percentage change in output Δ_{Y_0} can be translated into a percentage change in imports, out of the initial imports I_0, as: $\Delta_{I_0} = -\Delta_{Y_0} /(I_0 / Y_0)$ (3)

Now, the profits, which will be denoted by π, are defined as revenues minus costs. This means that before the regulatory policy change, the output level is Y_0 and profits could be written as:

$$\pi_0 = pY_0 - C(w,r,Y_0) \quad (4)$$

After the regulatory policy change, profits can be written as:

$$\pi_1 = pY_1 - C(w,r,Y_1) - mY_1 = (p-m)Y_1 - C(w,r,Y_1) \quad (5)$$

In short, increasing average costs of m per unit of output acts to reduce profits just like a reduction in output price from p to p-m.

In a competitive market, the basic assumption is that firms are choosing output levels that maximize their profits. The initial level of profits is denoted as in (4) above.

The level of output that maximizes profits in the initial situation can be written as:

$$Y_0 = Y(p,w,r) \quad (6)$$

which means that Y_0 is the level of output that maximizes profits when the output price is p, and input prices are w and r.

After the regulatory policy change, when profits are given by $\pi_1 = (p-m)Y_1 - C(w,r,Y_1)$ as in (5) the level of output is:

$$Y_1 = Y(p-m,w,r) \quad (7)$$

which means that Y_1 is the level of output (after the regulatory policy change) that maximizes profits when:

- *p-m* represents the output price that takes into account the increase in the average cost of production due to compliance with the regulatory policy change; and
- w and r are input prices.

To estimate the change in output from Y_0 to Y_1 from this price fall Larson et al (2002) showed that the percentage change in output, defined as $\Delta_{Y_0} = (Y_1 - Y_0)/Y_0$, can be calculated as:

$$\begin{aligned}\Delta_{Y_0} &= -[m/p] * E_{Yp} \\ &= -[mY_0/C_0] * [C_0/pY_0] * E_{Yp}\end{aligned} \quad (8)$$

When information is available to enable us to calculate *m/p* directly, the percentage change in output could be estimated directly as the supply elasticity (E_{Yp}) multiplied by the percentage change in the output price (-*m/p*).

The cost increase "*m*" is often not known directly, and information on *p* may not be available as well. Rather, information on compliance costs as compared to the existing costs (mY_0/C_0) and production values (pY_0) are more likely to be available particularly at the firm level. Thus, the form (8) is likely to be more generally useful for practical applications. The term mY_0/C_0 shows the percentage increase in costs due to the regulation. For notation, this means that: $\Delta_{C_0} = mY_0/C_0$ (9)

where Δ_{C_0} represents the percentage increase in costs above the initial level, which is called, the *cost factor*.

Using this additional notation, equation (8) can also be written as:

$$\Delta_{Y_0} = -\Delta_{C_0} * [C_0 / pY_0] * E_{Yp} \qquad (10)$$

Based on this definition of the change in output, the change in trade can be calculated as follows. Equation (10) above contains three main terms:

1. The cost factor: (Δ_{C_0}), which equals the compliance costs as a share of initial cost;
2. The profit factor: (C_0/pY_0), which equals the costs over revenues; and the
3. Supply elasticity: (E_{Yp}).

To calculate the effect on exports and/or imports, other information may be required. These are the initial share of exports from total production (E_0/Y_0) and the initial share of imports from total production (I_0/Y_0). The second term in equation (10) above is the profitability factor, which is defined as "initial costs relative to initial revenues". Since profits are basically some combination of costs and revenues, the ratio C_0/pY_0 is related to profitability as follows.

If we define the ratio of "profits" over costs as $r_0 = (pY_0 - C_0)/C_0$ the term r_0 is then a profit margin. After a little rearrangement, we have:

$$C_0/pY_0 = 1/(1+r_0) \qquad (11)$$

and for this the second term called the profitability factor.

To sum up, allowing for the possibility of efficiency improvements, the fundamental equation (8) needs to be adjusted slightly to:

$$\begin{aligned} \Delta_{Y_0}^{Y^e} &= -(\Delta_{C_0}) * (1-e) * (C_0 / pY_0) * E_{Yp} \\ &= \Delta_{Y_0} * (1-e) \end{aligned} \qquad (12)$$

where the notation $\Delta_{Y_0}^{Y^e}$ denotes the percentage change in output when the possibility of efficiency improvements are included into the analysis. Equation (12) is exactly the same as equation (8), except that $(\Delta_{C_0}) * (1-e)$

shows the overall percentage increase in initial costs due to compliance with the new regulation.

For the sake of completeness, we may consider the change in the prices received in the export destination markets due to the supply shifts. If the industry is too large and the environmental regulations induce changes in domestic production and therefore exports, it is possible that such supply shifts could in turn affect prices received in export destination markets. Two possibilities clearly exist where more stringent environmental regulations could induce export price adjustments.

To incorporate output price adjustments into the analysis additional notations related to the domestic and export demand functions are needed. For export demand, let:

- *D(p)* represent the export demand as a function of price, and
- *B = B(p)* represent the domestic demand as a function of price.

However, elasticities of demand with respect to the price (*p*), which is both the domestic price and the export price, will be needed for the analysis. Let E_{Dp} represent the elasticity of export demand with respect to price and let E_{Bp} represent the elasticity of domestic demand with respect to the price (*p*). We assume that the export price (*p*) clears the exports market where export demand equals export supply. Using our notation, this means that:

- $D(p) = Y(p, w, r) - B(p)$; and
- $p = p(w, r)$ is the equilibrium price

Taking the total differential of this equilibrium condition with respect to *p* and *w*, Larson et al (2002) found that the percentage increase in price (*p*) due to the more costly environmental regulations can be written as:

$$\Delta_{p_0} = \Delta_{Y_0} / \mathrm{A}, \quad \text{where} \qquad (13)$$

$$A = E_{Bp}\left(B_0 / Y_0\right) - E_{Yp} + E_{Dp}\left(E_0 / Y_0\right) \qquad (14)$$

To sum up, the percentage change in price (Δ_{p_0}) due to the regulatory change is simply a combination of the basic output effect Δ_{Y_0} divided by an adjustment factor "*A*" that depends on demand and supply elasticities and basic information on production, domestic demand, and export quantities. When export prices also adjust, more costly environmental regulations affect production levels not only because of the direct effect caused by costs rise but also because of the indirect effect due to the adjustment of output prices as costs rise.

The "direct effect" is simply Δ_{Y_0} as already has been calculated for the basic model or $\Delta_{Y_0}^{Ye}$ when efficiency improvements are included in the analysis. The "indirect effect" shows how output changes due to the percentage change in output price Δ_{p_0} as calculated above. Combining the two effects, we have:

$$\Delta_{Y}^{Y^p} = \left(\Delta_{Y_0}\right) + E_{Yp}\left(\Delta_{p_0}\right) \tag{15}$$

We note here that the percentage change in domestic consumption due to the price change can be computed as:

$$\Delta_B = E_{\mathrm{Bp}} * \Delta_{p_0} \tag{16}$$

Combining this change in domestic consumption with the change in domestic production, the percentage change in exports can be computed as:

$$\Delta_{E_0}^{E^p} = -\left(\Delta_{Y_0}^{Y^p}\right) * (Y/E) - \left(\Delta_B\right) * [(Y/E) - 1] \tag{17}$$

To implement this extension, information on the two demand elasticities and domestic consumption levels need to be acquired, where by definition, $B = Y - E$ for the export case.

Now, to study the impact of a proposed environmental policy on trade and development using the Larson model at the sector level and to examine the effects of two different policy instrument choices for policy makers to implement the proposed policy assuming uncertainty in the compliance costs we develop a model that incorporates the Jaffe *et al*. (2002) approach. We now consider an economic sector that consists of a variety of firms. In order to comply with the proposed policy measures, we assume that each firm owns a unit of a polluting technology, T_0 with a polluting emission $M = M_0$ and there exists a non-pollutant technology T_N. This technology could be new or additions or replacement to the existing technology that would be needed if the firm decided to comply with the new regulations. Following Jaffe *et al*. (2002) we assume that market-based instruments create more efficient incentives for firms to comply with the environmental policies than command-and-control policies. Using their approach, we estimate the total compliance cost for the underlying economic sector under two different policy instrument choices, taking an account of the uncertainty in the firms to comply with the new regulations and incorporate the results in the Larson model.

If the total number of firms in the sector is N and a fraction β of the firms adopts the new technology, the total sector's emissions become $M = N(1-\beta)M_0$. Each firm i is characterized by a compliance cost parameter c_i which captures the cost of adopting T_N. Since the uncertainty is mainly in the compliance cost of the firms, the c_i's are assumed to be independent and identically distributed random variables from the uniform distribution on the interval $[0, \alpha]$ with a probability density function given

by $f(x,\alpha)=\frac{1}{\alpha}$. The maximum likelihood estimator for the parameter α is given by $max(c_i)$ which is the maximum cost of adopting the new technology T_N for a firm in the underlying sector (Okasha and Al-Krunz; 2001). For an individual firm there are no benefits from adopting T_N and no firm will adopt it without government intervention. The policy makers however, can choose the option to compel firms to adopt T_N which we will refer to as direct regulation (*DR*). Under direct regulation all firms will adopt T_N. Among the consequences of this option are polluted emissions would be completely eliminated, ($i.e.\, M_{DR}=0$), and firms would fully bear the compliance costs by adopting T_N. Direct regulation thus affects the financial position of the firms. The expected effect of *DR* on the financial position of the entire sector is given by $F_{DR}=-N\beta.\int_0^{\alpha} c_i \frac{1}{\alpha} dc_i = -\frac{N\beta\alpha}{2}$.
Alternatively, the policy makers can choose the option to subsidize the new technology. We assume that the policy makers know the distribution of the c_i's, but do not observe the compliance cost for specific firms. Under this option, the policy makers can not offer firm-specific subsidies but can choose a subsidy *S*, and firms can decide whether or not to adopt T_N. Among the consequences of this option is the reduction of the polluted emissions. If we assume that all firms for which $c_i \le \mathrm{S}$ adopt T_N, the expected pollution would reduce to $M_S=\int_S^{\alpha} N\beta M_0 \frac{1}{\alpha} dc_i = N\beta M_0(1-\frac{S}{\alpha})$.
Other consequences include the expected public expenditure, $G_S=-N\beta\int_0^{S} c_i \frac{1}{\alpha} dc_i = -\frac{N\beta S^2}{2\alpha}$ and the expected financial position of the entire sector, which is the expected expenditure of the entire sector on T_N, is $F_S=-N\beta\int_S^{\alpha}\frac{1}{\alpha}.c_i dc_i = -N\beta\left(\frac{\alpha^2-S^2}{2\alpha}\right)$, while the expected sector's receipts are $\frac{N\beta \mathrm{S}^2}{2\alpha}$. This shows that the choice between direct regulation and subsidies affects polluting emissions and has distributional consequences.
The policy makers are concerned with the distributional consequences of the environmental policy and care about the environment. Their preferences can be described by the following expected utility function:

$$E(U) = F - \lambda_1.M^2 - \lambda_2.G \qquad \text{with } \lambda_1 > 0 \text{ and } \lambda_2 > 1 \quad (18)$$

where λ_1 denotes the weight that the policy maker attributes to the environmental target relative to the distributional issue. The interpretation of the parameter λ_2 is that it captures who should bear the costs of environmental policy. The assumption $\lambda_2 > 1$ then implies that the policy maker finds the financial position of the government more important than that of the sector. An alternative interpretation of λ_2 is that costs are attached to donor supports or collecting taxes required to finance public expenditures on the environmental regulations. The quadratic utility function in (18) has been employed for mathematical tractability. However, we believe that formula (18) fit reasonably well with studying the consequences of environmental policy for the competitiveness of the sector and for public expenditures. Other advantage for this simple model is that it enables us to focus on the implications of uncertainty and asymmetric information for the evaluation of alternative policy instruments (Brainard, 1967). However, we are aware that the model is rudimentary. It is well-known that subsidies may encourage polluting activities whereas direct regulation may discourage polluting activities. We ignore this aspect by assuming that the choice of instrument does not influence production decisions.

Now, we evaluate *DR* and *S* using equation (18) and the outcomes under *DR*. It immediately follows that the policy makers' utility equals:

$$U_{DR} = -\frac{N\beta\alpha}{2} \qquad (19)$$

Suppose that *S* is the instrument. The optimal value of *S* results from maximizing (18) with respect to *S*, given the outcomes of *S*. This yields:

$$S = \frac{N\beta\lambda_1 M_0^2}{\frac{\lambda_1 M_0^2}{\alpha} + \lambda_2 - \frac{1}{2}} \qquad (20)$$

This result shows that *S* increases with λ_1, α and M_0, and decreases with λ_2. Substitution of (20) into (18) gives the policy makers' expected utility under *S* as follows:

$$U_S = -\frac{N\beta\lambda_1 M_0^2(\lambda_2 - \frac{1}{2})}{\frac{\lambda_1 M_0^2}{\alpha} + \lambda_2 - \frac{1}{2}} \qquad (21)$$

From (19) and (21) it is easy to show that *S* is given preference over *DR* if :

$$\alpha > \alpha^{l} = \frac{2\lambda_1 M_0^2(\lambda_2 - 1)}{\lambda_2 - \frac{1}{2}} \quad (22)$$

where α^{l} denotes the value of α for which the policy maker is indifferent between *DR* and *S*. From the above analysis one can conclude the following results:

1. If $\lambda_2 \leq 1$ (contrary to what we have assumed), then *DR* is always superior to *S*.
2. If $\lambda_2 > 1$ (as assumed), then the policy makers prefers *S* to *DR* when the sector's compliance costs are high (high α).
3. The attractiveness of *DR* decreases with λ_1 and M_0.

Because the marginal benefits of reducing emissions go to *zero* if *S* goes to α, flexibility is an attractive property of an instrument (as long as the marginal benefit of reducing emissions is higher than α when M_0 goes to *zero*). This also means that, if the policy makers could observe the c_i's, then under *DR* they would exempt high cost firms from the obligation to adopt T_N. Clearly, the more the policy makers care about the environment (higher λ_1), the less they value flexibility. The advantage of *DR* however, is that it does not involve seeking foreign support or a costly redistribution from government to the sector.

From the above discussion, we conclude the following two relevant results to the development and application of the Larson model at the sector level. First, the government could maximize its utility by computing the utility or choosing one of the two instruments. The second result is that the expected compliance cost under the direct regulation instrument *DR* for the entire sector to comply with the proposed environmental standards would be $-\frac{N\beta\alpha}{2}$. However, under the subsidies option the expected compliance cost that the entire sector would have to pay in order to comply with the proposed environmental standards would be $-\frac{N\beta(\alpha^2 - S^2)}{2\alpha}$. The value of *S* could be selected according to the availability of funds to subsidize the new technology. The expected public expenditure would equal $-\frac{N\beta S^2}{2\alpha}$ which equals the total contribution of the government to the sector. The minus signs here indicate that the above amounts are costs.

In the later sections, we apply the Larson model at the firm level, and the modified model at the sector level on three selected sectors. The choices of the environmental policy measures and the selected sectors are discussed in the next two sections.

II. Choice of the suggested environmental policy measures:

The suggested environmental policy selected for studying its impact on trade and competitiveness in the present paper is the most recent version of the Palestinian environmental law to regulate the effluent quality standards for sewage works, industrial discharge and wastewater reuse. The law was a concession between the best environmental quality standards and the economic development. It is a set of pollutant parameter values that were ranging between those of the neighboring countries and the international standards.

The proposed industrial effluent standards are simply the thresholds for release into the municipal sewage network and given in table (1).

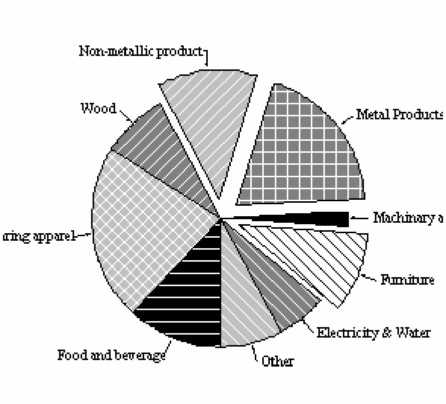
Table (1): Standards for industrial wastewater discharge to the sewerage system.

Parameter	Unit	Max. Value	Parameter	Unit	Max. Value
Temperature		25	Ammonium (NH_3)	mg / L	45
PH	pH units	6-9	Mercury	mg / L	0.05
Color	PCU	150	Lead	mg / L	1
BOD_5	mg O_2/L	500	Beryllium	mg / L	0.5
COD	mg / L	2000	Arsenic	mg / L	0.25
NH_4	mg / L	>1	Cadmium	mg / L	0.5
Total dissolved solids	mg / L	2500	Copper	mg / L	2
Total Suspended solids	mg / L	500	Nickel	mg / L	1
Turbidity	NTU	50	Iron	mg / L	50
Sulphates	mg / L	1000	Manganese	mg / L	5
Oil & grease	mg / L	100	Zinc	mg / L	5
Artificial Detergents	mg / L	25	Sodium	mg / L	230
Phosphates (PO_4)	mg / L	15	Barium	mg / L	2
Nitrates (NO_3)	mg / L	30	Cobalt	mg / L	1
Phenols	mg / L	3	Total pesticides	mg / L	3
Magnesium	mg / L	150	Total Kjeldahl Nitrogen	mg / L	60
Fluorides	mg / L	2	Cyanides	mg / L	1
Boron	mg / L	3	Mineral oil	mg / L	20
Aluminum	mg / L	10	Residual Chlorine	mg / L	3

Source : EQA (2001).

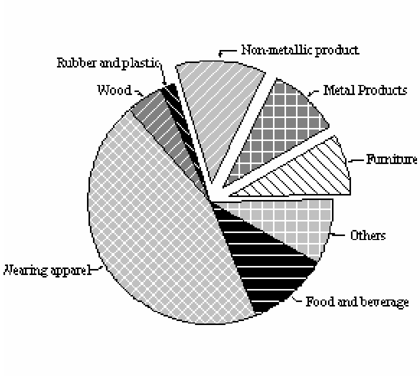
III. Choice of the manufacturing sectors:

The selected industrial sectors for the present study are the electroplating industry, the non-metallic mineral (tiles and marble) industry and the bamboo furniture industry. The choice of those industries as important manufacturing sectors to be examined have been due to their role in exports, imports, employment, and income generation as well as their water consumption in Palestine. The electroplating industry comprises a wide range of products including all kinds of treatment and coating of metals; general mechanical engineering on a fee or contract basis. The Gaza Strip accommodates also a large number of non-metallic mineral industrial firms mainly tiles and marble factories that produce for local markets and for exports. Data on tiles and marble industries are dominating production, import and output data of the non-metallic industry in the official statistics (PCBS, 2003). Therefore, we limit our discussion regarding the non-metallic mineral industry on tiles and marble industry. Gaza also accommodates a large number of wooden and bamboo workshops that produce for local markets and for exports. Electroplating workshops and tiles and marble industries are among the biggest effluent producing factories in the Gaza Strip. Therefore, in the present paper we concentrate on three specific industries: the electroplating industry, the tiles and marble industry and the bamboo furniture industry.



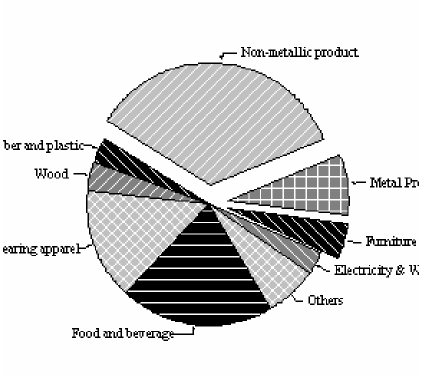
Source: PCBS; Unpublished data (2003).

Fig(1): Number of Firms in differet Industrial branches in the gaza Strip (2000).



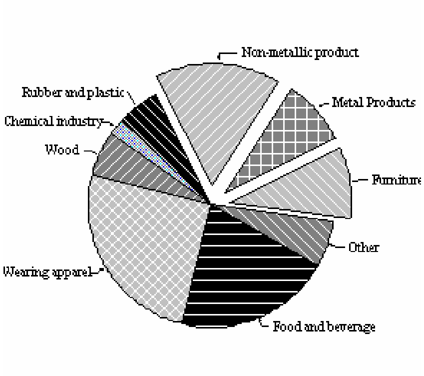
Source: PCBS; Unpublished data (2003).

Fig(2): Employment in Industrial Branches In the Gaza Strip (2000).



Source: PCBS; Unpublished data (2003).

Fig(3):Water consumption by different industrial branches in the Gaza Strip (2000).



Source: PCBS; Unpublished data (2003).

Fig(4): Value added by different industrial branches in the Gaza Strip (2000).

Analogous to all other industrial branches in the Gaza Strip, electroplating industry, tiles and marble industry and the bamboo furniture industry are characterized by small, fragmented and family owned workshops. Official statistics (PCBS, 2003) show that fabricated metal (electroplating) production employs 9.5% of the total employment in industry in the Gaza Strip; and its share in the value added is 8.6% of the total share of the industrial sector. However, electroplating industry consumes 8.0% of the total industrial water consumption and it is one of the largest wastewater effluent producing industries in the Gaza Strip. Official statistics shows also that non-metallic mineral industry, which includes mainly tiles and marble industries, employs 11.8% of the total employment in the industrial sector; and its share in the value added is 16.6% of the total share of the industrial sector. Furniture industry employs 8.1% of the total employment in the industrial sector; and its share in value added is 9.4% of the total share of the industrial sector. The above facts can be seen clearly in figures 1-4 above.

IV. Data sources and limitations:

Data were collected through structured interviews with firm managers using a survey of firms operating in the three sectors, informal interviews with business associations, consultation with the Palestinian Central Bureau of Statistics (PCBS), environmental engineers in Palestinian Industrial Estates and Free Zones Authority (PIEFZA), and engineers and officials in the Environment Quality Assurance Authority (EQA). The main concern has been to gather data and relevant information on production cost structures and the ability of firms to respond to the proposed environmental policy measure. Data on the total values of production, exports, imports per sector and the cost share in total production costs of the main categories of inputs used in the production process of each sector being examined are published in previous studies and in the PCBS publication but not classified in detail by Palestinian Governorates (PCBS, 2002). Consequently, unpublished data on the Gaza Strip Governorates level were obtained by a special request from the PCBS.

Moreover, sector-specific output own price elasticities and information on returns to scale as well as information on the firm level were obtained through structured interviews with firm managers using a survey of firms operating in the sector and interviews with business associations. The survey covered all firms operating at present (as of January-March 2003) in the sectors and still exporting and/or importing the sector's products.

It is worth stating that due to the current political situation in the Gaza Strip which creates difficulties in exporting and importing goods through the borders, many firms that were able to produce, export and import are temporarily out of business, permanently closed or still producing only for local markets. This creates difficulties in the data collection and variations in the statistics between different sources particularly for the years 2001 and 2002. Consequently, data of the year 2000 on the total values of production, exports and imports at the sector level are used. More recent primary data (for the year 2003) collected using a questionnaire applied to firms operating at present in one of the three sectors were obtained and used to estimate some parameters at the firm level.

The field survey covered all firms operating in the electroplating, tiles and marble, and bamboo furniture industrial sectors and have the ability at present to export and/or import goods. The total number of firms operating in the electroplating business but not necessarily trade as of the year 2000 was 16, in the non-metallic mineral industrial sector was 482 and in the furniture industrial sector was 383. However, the field survey revealed that the total number of firms operating in the electroplating sector is 8 in 2003, 263 in the tiles and marble industrial sector and 184 in the furniture industrial sector. Among those there are only 5 firms that still have the ability to trade in the electroplating sector, 9 in the tiles and marble sector and 27 in the bamboo furniture sectors. Those firms were included in the survey but only 4 electroplating firms, 6 non-metallic mineral firms and 18 furniture firms have responded and gave details about their activities in the interview. Estimates of the important parameters at the sector level for each sector were thus obtained.

V. Key economic indicators:

In order to apply the model at the sector's level, a set of key indicators, as of the year 2000, which are necessary as model parameters are used. Those are classified in table (2) below. The year 2000 has been considered for the analysis because it was the last politically stable year in the Gaza Strip in which most industrial firms were functioning in their full capacity and most of the needed data are available at the sector's level. Data on production, input and output for each sector was obtained from official sources particularly from the PCBS. Some of the data are unpublished and were kindly provided by a special request from the PCBS. Most parameters were easily computed using the available data.

Supply elasticities which are needed for both the Larson model at the firm level and the modified model at the sector level, have been estimated using the survey data as the average of ordinal variables obtained by questioning producers in the three sectors about their opinions on the percentage changes in the quantity supplied due to a 100% increase in the price of the products. The estimated elasticity for all sectors are roughly the same and was approximately 0.8 and this estimate was considered for all sectors. That is, a 100% rise in the price of the unit product in the sector would lead to about 80% rise in the supply of the electroplated products.

Table 2: Some Economic Indicators on the Three Industrial Sectors in the Gaza Strip

Industry:	Electroplating	Non-Metallic Mineral	Furniture
1. Key Statistics :			
Number of Firms	16	482	383
Number of Workers	143	2764	1898
2. Production :			
Total Production	5,942.7	71,197.1	35,879.3
Intermediate Consumption	4,088.2	44,610	20,818.4
Compensation of Workers	280.2	5,442.3	3,610.2
Gross Fixed Capital Formation	21.4	611	191.3
Total Inputs	4,389.8	50,663.3	24,619.9
Gross Value Added	1,854.5	26,587.1	15,060.9
3. Inputs :			
Total Inputs of Goods	3,808.0	42,515	19,701.7
Raw Materials	N.A.	34,607.9	18,228.1
Fuel and Oil	N.A.	5,793.7	324.8
Electricity	N.A.	738	300.1
Water	N.A.	207.4	28
Packing and Wrapping Materials	N.A.	126.4	122.1
Spare Parts	N.A.	672.3	119.3
Disposables	N.A.	271.7	82.4
Stationery	N.A.	38.7	25.5
Other	N.A.	58.9	471.4
4. Exports and Imports :			
Total Exports	2,990.25	21,360	5,928.09
Total Imports	40,012.58	48,106	5,013.49
5. Other Parameters :			
Imports as Share of Total Production	6.733	0.676	0.140
Domestic Production/Consumption	0.138	0.727	1.026
Supply Elasticity	0.8	0.8	0.8
Exports Share of Total Production	0.503	0.30	0.165
Imports as Share of Consumption	0.931	0.491	0.143
Consumption	42,965.03	97,943.1	34,964.7

Source : PCBS (*2002*) and *PCBS* (*2003*)

VI. Estimating the compliance cost to the proposed effluent standards:

A key issue for the models of the present study is to find out the new technology required by the industrial firms in each of the underlying industrial sectors to comply with the proposed environmental policy standards as well as the cost of the required technology. To do this it is important to assess the quality of wastewater discharged from the industry and the state of compliance with the standards. The compliance cost would then be the cost of investment necessary for the industry to be in compliance with the proposed environmental standards. It should be noted here that in the Gaza Strip alternative non-polluting technology and wastewater treatment technology are not available at present in the local markets because of the lack of demand for the new technology and wastewater treatment units and, thus foreign markets should be sought. However, as soon as the proposed wastewater policies were indorsed and became enforce a new market for the new technology and the wastewater treatment units would emerge. It is expected that in such a new market the compliance costs would be less than those at present exported from foreign markets. As a result, it is expected that any estimate for the compliance cost for a single industrial firm before the enforcement of the law would not be exact for all firms in the same sector because of the expected emergence of the new local market for the technology and wastewater treatment units. Fortunately, the estimate of the compliance cost required for the model at the sector level is the maximum compliance cost needed by the firm in the sector. This means that, it is only necessary to estimate the compliance cost for the worst polluting firm in each of the three industries.

For an industrial firm in any of the three sectors in the Gaza Strip, and according to the specific quantities and qualities of the effluent it is possible to get a prefabricated industrial compact unit for each industrial firm not in compliance. We will assume here that each firm would initially choose the option of installing a prefabricated industrial compact unit rather than investing in a costly new technology. Since the cost of treating one cubic meter of industrial wastewater using the prefabricated industrial compact unit can vary widely as the type of effluent varies, it is thus necessary to obtain information on the amount and type of wastewater effluent as well as other information including the flow rate and pressure of the effluent in order to design the required prefabricated industrial compact unit for the firm and to estimate its cost (Jurickova 2002 & Mohamed, 2001). Achieving a good estimate for the compliance cost for a firm requires assessing the quality of wastewater discharged and the state of compliance with the proposed environmental standards for the firm (Palenik and Kotov, 2002). Therefore, several compact samples of wastewater from the worst effluent producing industrial firm should be analyzed for some parameters that are necessary to identify the required technology for that firm to comply with the proposed environmental standards (Dasgupta *et al* 2001). At the present circumstances the analysis of wastewater samples in the Gaza Strip can only be performed in private laboratories including those of the local universities. This however, is a very expensive process and the cost of the analysis would be further expenses that should be added to the compliance cost unless a new governmental laboratory has been established. For a selected industrial firm in each of the chosen sectors in Gaza as the worst effluent producing firm, a compact sample of wastewater in a single day has been analyzed for some parameters that were thought to be important. The results of the analysis are given in table 3. It should be noted that the results of wastewater analysis of a compact sample in one day for a firm would not be sufficient to obtain an accurate estimate of the cost of installing a prefabricated industrial compact unit for the firm. It is merely an example showing the quality of wastewater for this industry.

Since, the impact of the above environmental standards on trade and competitiveness of the electroplating industry, the non-metallic mineral industry and the furniture industry is the core of the present paper, only a few of the above parameters are relevant (Agarwal, 2002 and Rose, 1996). As has been discussed above, and according to several sources including those of the Palestinian Industrial Estate and Free Zone Authority (PIEFZA, 1999), the most relevant parameters for testing in the electroplating industry are Zn, Fe, Ni, Cn, pH, TDS, Cr and Cu., in the non-metallic mineral industry are TDS, SS, NO_3 , COD and BOD, and in wooden and bamboo industry are color, COD, BOD and pH but the most relevant parameters in metallic furniture industry are color, COD, BOD, pH, Cr and Fe. However, the industrial firms in general vary widely in terms of quality of wastewater they discharge and many firms are producing other hazardous materials.

The results of wastewater effluent analysis in the electroplating industry in table (3) below demonstrate that all the parameters in the sample are nearly high and most of them exceeded the thresholds. This is despite the fact that all the thresholds, particularly for COD at 2000 mg/l, being proposed for adoption by EQA are quite high given that there is no separate industrial treatment unit and that the municipal wastewater treatment unit is not functioning properly in Gaza. However, the effluent analysis in the tiles industry demonstrates that only NO_3 exceeds the standards by about 250% and none of the parameters in the furniture industrial firm's sample exceeds the threshold which indicates that the firm could be in compliance with the proposed environmental standards. Moreover, frequent analysis of wastewater samples and tests for other parameters are not readily available for any firm while those are necessary for designing a prefabricated industrial compact unit and for computing the exact compliance cost to the proposed effluent standards. However, frequent wastewater analysis for many parameters would be unnecessary because of the fact that exact values for compliance costs would not be reached before designing the prefabricated industrial compact unit due to reasons discussed above.

Table 3 : The Analysis of Compact Samples of Wastewater from Three Different Pollutant Industrial Firms Selected from the Three Industrial Sectors (The analysis was conducted in Water Research Center in the IUG).

Parameters	Results of the analysis	threshold
An Electroplating Industrial Firm :		
PH	9.1	6-9
COD mg/l	650	2000
CI mg/l	1060	
SO4 mg/l	2500	230
Ni mg/l	280	1
Cr mg/l	160	2
Pb mg/l	0	15
A Tiles Industrial Firm :		
Total Solids (TS) mg/l	10400	3000
Total dissolved solids (TDS) mg/l	2800	2500
Suspended solids (SS) mg/l	7600	500
BOD mg/l	10	500
COD mg/l	180	2000
NO_3 mg/l	79.7	30
NH_3 mg/l	NIL	45
A Bamboo Furniture Industrial Firm :		
Total Solids (TS) mg/l	1900	3000
Total dissolved solids (TDS) mg/l	1800	2500
Suspended solids (SS) mg/l	100	500
BOD mg/l	200	500
COD mg/l	406	2000
NO_3 mg/l	10.92	30

Since no research has been conducted on the cost of treatment of the industrial wastewater in US currency and in local prices neither there exist a market for wastewater treatment technology in Palestine, some of the foreign wastewater treatment companies which are most likely that the Palestinian firms would buy the technology from were contacted (ODIS; 2002 and CHEMTEC; 1988). Responses received from wastewater treatment companies indicated that expensive frequent analysis of wastewater samples were not necessary for a company with a high profile in wastewater treatment technology in different countries to give an estimate for the maximum compliance cost for a firm in a specific industrial sector (AMIAD, 1997 and TAHAL 2003). Rather, other parameters concerning the size of the firm and the average flow rate and pressure of the effluent are of more importance. For an industrial firm working in the electroplating industry with a size and average flow rate and pressure similar to those in the Gaza Strip, the estimated maximum compliance cost has been estimated at $45,000. The maximum compliance costs for an industrial firm working in the tiles industry similar to those in Gaza and bamboo furniture industry were estimated at $35,000 and $25,000 respectively. The working age of such a prefabricated industrial compact unit according the company's profile is about 10 years. The above costs would however be paid prior to the installation of the plant. For simplicity, we will assume that the firms would be able to get easy loans to buy the technology at an annual interest rate of 7%. Doing this would be equivalent to computing the present value of each installment towards the compliance cost for ten years at 7% interest rate for companies that would not get loans. For the electroplating industrial firm, the annual equal payments to pay back the loan for such compliance cost would be $6,407 and the annual direct compliance cost after adding a 5% operation and maintenance to the investment cost would be $8,657. For the tiles and bamboo furniture industrial firms the annual equal payments to pay back the loan for such compliance cost would be $4,983 and $3,559. The annual direct compliance cost after adding a 5% operation and maintenance to the investment costs above would be $6,733 and $4,809 for the same firms respectively.

VII. Application of the Larson model at the firm level:

Detailed data at the firm level are available from 40 operating firms in the three industrial sectors in the Gaza Strip. The Larson model has been applied on each of those firms separately. An example for a firm in each of the three industrial sectors is described below. The examples can be considered as for typical firms in each of the three selected industrial sectors in the Gaza Strip for the purpose of estimating the impact of complying with wastewater effluent standards on trade and competitiveness.

The number of produced units and the average unit price were estimated using the available data as each firm produces several types of products sharing the same raw materials. In such a situation, a weighted average for the unit price for each type of products was computed and used as an estimate for the firm's unit price. Values of the model parameters are given in table 4 below. It is assumed that each firm would save on average about 15% of the total cost as a result of efficiency improvements and as a compensation for some of the losses incurred from complying with the environmental standards. The "profitability" factor, which is indicated as "costs as a share of revenues" in the results in table (5), is estimated at 0.618

for electroplating industrial firm, 0.519 for the tiles industrial firm and 0.879 for the bamboo furniture industrial firm.

Table(4): The Larson Model's Parameters for the three selected Industrial Firms.

Larson Model's Parameters:	Notation	Electro-plating firm	Tiles Firm	Bamboo Firm
Output Level (Number of produced units)	Y_0	1862400	127750	5000
Initial Costs	C_0	92000	331743.0	3340475.0
Initial Average Costs	C_0 / Y_0	0.0494	2.597	668.095
The Annual Direct Compliance Cost ($)	α	8657	6733	4809
Weighted Average Unit Price ($/unit)	p	0.08	5	760
Initial Revenues	$p.Y_0$	148992.0	127750.0	3800000.0
Average Production Costs	$(C_0 + \alpha) / Y_0$	0.054	2.650	673.095
Increase in Average Costs	$m = \alpha / Y_0$	0.00465	0.053	0.9618
Supply Elasticity	E_{Yp}	0.8	0.8	0.8
Efficiency Improvements	e	15%	15%	15%
Exports as a Share of Total Production	E_0 / Y_0	0.76	0.30	0.9
Compliance Costs as a Share of Initial Cost	$\Delta_{C_0} = mY_0 / C_0$	0.0941	0.0203	0.00144
Profit Margin	$r_0 = (pY_0 - C_0)/C_0$	0.619	0.925	0.138
Costs as a Share of Revenues	$C_0 / pY_0 = 1/(1+r_0)$	0.618	0.519	0.879

Table(5) : The Effect of Complying with the Proposed Wastewater Effluent Standards Estimated Using the Larson Model for Three different Industrial Firms in Gaza.

Output of the Larson Model :	Notation	Electro-plating firm	Tiles Firm	Bamboo Firm
The Basic Model :				
Compliance Costs as a Share of Initial Cost	$\Delta_{C_0} = mY_0 / C_0$	0.0941	0.0203	0.00144
Percentage Change in Output	Δ_{Y_0}	-0.04650	-0.008	-0.00101
Percentage Change in Exports	Δ_{E_0}	-0.06118	-0.028	-0.00112
With Efficiency Improvements :				
Percentage Change in Output	$\Delta_{Y_0}^{Y^e} = \Delta_{Y_0} * (1-e)$	-0.03952	-0.007	-0.00086
Percentage Change in Exports	$\Delta_{E_0}^{E^e} = \Delta_{E_0} * (1-e)$	-0.05200	-0.024	-0.00096

The model results in table (5) show that complying with the proposed wastewater effluent standards would cause the electroplating industrial firm a 4.65% decrease in output. The effects of complying with the proposed wastewater effluent standards on the exports of the company would be a decrease of 6.12% of its total exports. Since the decrease in output is not so large, the effect of efficiency improvements on the output and exports of the firm would also be very small. Therefore a 15% efficiency improvement would reduce the effect to a 3.95% reduction of the total output and a decrease of 5.2% of the total exports of the company. For the tiles industrial firm, the results show that complying with the proposed wastewater effluent standards would cause a 0.8% decrease in output. Moreover, the effects of complying with the proposed wastewater effluent standards on the exports of the tiles firm would be a decrease of 2.8% in its total exports. Since the decrease in output is very small, the effect of efficiency improvements on the firm's output and exports would also be very small. Therefore, a 15% efficiency improvement would reduce the effects to a 0.7% reduction of the total output and a 2.4% reduction of the total exports of the firm. Moreover, for the bamboo furniture industrial firm, the results show that complying with the proposed wastewater effluent standards would cause a 0.1% decrease in output. The effects of complying with the proposed wastewater effluent standards on the company would also be a decrease of 0.112% of its total exports. The effect of efficiency improvements on the output and the exports of the firm would thus be negligible. Therefore a 15% efficiency improvement would reduce the effect to a 0.086% reduction in the total output and a decrease of 0.096% of the total exports of the company. We could have allowed for price adjustment in the Larson model but this has not been considered here because it is not expected that the Gaza Strip production in any of the three industrial sectors is so large that it would affect the prices of the products in the international markets.

VIII. Application of the modified model at the sector level:

Recent data on any of the three industrial sectors or on the industrial firms that still have the ability to export and import, in the Gaza Strip are not at present available because of many obstacles on data collection during the currant political crises in the Palestinian Territories. Moreover, due to the same reasons and the frequent closures of the borders, many of the firms stopped trading and others stopped their business temporarily or permanently . Therefore, formal data as of the year 2000, which was a stable year, are obtained for the each of the sectors and summarized in table(2) above. The number of produced units and the average unit price, for each sector, which is needed as an important parameter for the model, was estimated using the available official statistics. This is due to the fact that each industrial sector produces several types of products with different unit prices sharing the same raw materials. Thus, a weighted average for the unit price of all types of products in the sector was computed and used as an estimate for the unit price in each industrial sector. Values of the modified model's parameters, which are explicitly given, in the official statistics and the ones estimated for other model entries are given in table 6 below.

Table 6: The modified model's parameters for each industrial sector

Modified Model's Parameters:	**Notation**	**Electro-plating Sector**	**Tiles Sector**	**Bamboo Sector**
Output Level (Number of produced units)	Y_0	74283750	14239420.0	47200
Initial Costs	C_0	4389800	50051561.3	24619900.0
Initial Average Costs	C_0 / Y_0	0.0591	3.515	521.608
Weighted Average Unit Price ($/unit)	p	0.08	5.0	760
Initial Revenues	$p.Y_0$	5942700.0	71197100.0	35872000.0
Supply Elasticity	E_{Yp}	0.8	0.8	0.8
Efficiency Improvements	e	15%	15%	15%
Exports as a Share of Total Production	E_0 / Y_0	0.503	0.30	0.165
Profit Margin	$r_0=(pY_0-C_0)/C_0$	0.345	0.422	0.457
Costs as a Share of Revenues	$C_0/pY_0=1/(1+r_0)$	0.743	0.703	0.686
Under Direct Regulations:				
Annual Compliance Cost	α	61561.0	556356.0	184201.0
Average Production Costs	$(C_0 + \alpha) / Y_0$	0.0599	3.554	525.511
Increase in Average Costs	$m = \alpha / Y_0$	0.0008	0.039	3.903
Compliance Costs as a Share of Initial Cost	$\Delta_{C_0} = mY_0 / C_0$	0.01402	0.011	0.0075
Expected total compliance cost	$\frac{N\ \beta\alpha}{2}$	320000	2892000	957500
Under USD 2.0 million Subsidies:				
Annual Compliance Cost	α	23085.0	287027.0	107250.0
Average Production Costs	$(C_0 + \alpha) / Y_0$	0.0591	3.535	523.880
Increase in Average Costs	$m = \alpha / Y_0$	0.0003	0.020	2.272
Compliance Costs as a Share of Initial Cost	$\Delta_{C_0} = mY_0 / C_0$	0.00526	0.0057	0.0044
Sector's expected public expenditure (Subsidies)	$G = \frac{N\beta S^2}{2\alpha}$	200000	1400000	400000

The value of *S*	$\sqrt{\frac{2\,\alpha\,G}{N\,\beta}}$	31622.78	20873.06	12926.79
Sector's expected compliance cost	$\frac{N\beta(\alpha^2 - S^2)}{2\alpha}$	120000	1492000	557500

It is expected that each industrial sector would save about 15% of its total initial costs as a result of efficiency improvements in order to compensate some of the losses incurred by complying with the environmental standards. The maximum compliance costs including the investments in the prefabricated industrial compact unit and the cost of installation has been estimated at $45,000 for each electroplating industrial firm in the previous section but allowing for a decrease in the price of the units due to the growing business of such units a better estimate for maximum compliance cost would be about $40,000. Moreover, since this industry is one of the highly polluting industries and they are well known few workshops, it is expected that all the available electroplating firms will be required to comply with the environmental standards. This makes the expected compliance cost for all 16 firms in the sector as $320,000. The annual compliance cost, as a 7% interest rate loan of 10 equal annual payments, and adding a 5% operation and maintenance costs to the investment cost is estimated at $61,561 under DR and at $32,085 under government subsidies of $200,000 to the sector. For the non-metallic mineral industrial sector, the maximum compliance cost has been estimated at $35,000 per unit in the previous section but allowing for a decrease in the price of the prefabricated industrial compact units a better estimate of the maximum compliance cost per firm would be $30,000. Moreover, it is expected that only 40% of the available 482 firms working in the non-metallic mineral industry will be required to comply with the environmental standards since many firms in the sector are very small family owned workshops and most probably will not comply with the standards and some would be able to show evidence that they are in compliance. This makes the expected compliance cost for all firms in the sector as $2,892,000. The expected annual compliance cost as a 7% interest rate loan of 10 equal annual payments and adding a 5% operation and maintenance cost to the investment costs is estimated at $556,356 under DR and at $287,027 under government subsidies of $1,400,000 to the sector. Furthermore, for the furniture industrial sector, the maximum compliance cost has been estimated at $25,000 per unit in the previous section but allowing for a decrease in the price of the prefabricated industrial compact units a better estimate would be $20,000 per firm. Moreover, it is expected that only 25% of the available 383 firms working in the furniture industry will be required to comply with the environmental standards. This makes the expected compliance cost for all firms in the sector as $957,500. The annual compliance cost, as a 7% interest rate loan of 10 equal annual payments, after adding a 5% operation and maintenance cost to the investment costs is estimated at $184,201 under DR and at $107,250 under government subsidies of $400,000 to the sector.

The results of applying the modified model on each of the three industrial sectors, using the above data, are reported in table (7) below. The "profitability" factor, which is indicated as "costs as a share of revenues" in table (6) is estimated at 0.743 for the electroplating industrial sector, 0.703 for the non-metallic mineral industrial sector and 0.686 for the furniture industrial sector.

Table 7: The Effect of Complying with the Proposed Wastewater Effluent Standards for Each of the Three Industrial Sectors in Gaza Strip.

Output of the Modified Model :	**Notation**	**Electro-plating Sector**	**Tiles Sector**	**Bamboo Sector**
Under Direct Regulations:				
The Basic Model :				
Compliance Costs as a Share of Initial Cost	$\Delta_{C_0} = mY_0/C_0$	0.01402	0.0110	0.0075
Percentage Change in Output	Δ_{Y_0}	-0.008	-0.006	-0.004
Percentage Change in Exports	Δ_{E_0}	-0.017	-0.021	-0.025
With Efficiency Improvements :				
Percentage Change in Output	$\Delta_{Y_0}^{Y^e} = \Delta_{Y_0} * (1-e)$	-0.007	-0.005	-0.004
Percentage Change in Exports	$\Delta_{E_0}^{E^e} = \Delta_{E_0} * (1-e)$	-0.014	-0.018	-0.021
Under USD 2.0 million Subsidies:				
The Basic Model :				
Compliance Costs as a Share of Initial Cost	$\Delta_{C_0} = mY_0/C_0$	0.00526	0.0057	0.0044
Percentage Change in Output	Δ_{Y_0}	-0.003	-0.003	-0.002
Percentage Change in Exports	Δ_{E_0}	-0.006	-0.011	-0.015
With Efficiency Improvements :				
Percentage Change in Output	$\Delta_{Y_0}^{Y^e} = \Delta_{Y_0} * (1-e)$	-0.003	-0.003	-0.002
Percentage Change in Exports	$\Delta_{E_0}^{E^e} = \Delta_{E_0} * (1-e)$	-0.005	-0.009	-0.012

The results show that complying with the proposed wastewater effluent standards would cause the electroplating industrial sector a 0.8% decrease in output under DR and a 0.3% decrease in output under S. However, the reduction in output would reduce to 0.7% under DR and remain about 0.3% under S when taking an account of 15% efficiency improvement. The effect of complying with the proposed wastewater effluent standards on the total exports of the electroplating sector would be a reduction of 1.7% under DR and 0.6% under S. However a 15% efficiency improvement would reduce to 1.4% under DR and to 0.5% under S reduction in the total exports of the electroplating sector. The results also show that complying with the proposed wastewater effluent standards would cause the output the non-metallic mineral sector a 0.6% decrease under DR and a 0.3% decrease under S. However, the reduction would reduce to 0.5% under DR and remain about 0.3% under S when taking account of 15% efficiency improvements. The effect of complying with the proposed wastewater effluent standards on the total exports of the non-metallic mineral sector would also be a decrease of 2.1% under DR and of 1.1% under S. However a 15% efficiency improvement would reduce the effect to 1.8% under DR and to 0.9% under S reduction of the total exports of the sector. Moreover, the results show that complying with the proposed wastewater effluent standards would cause the output of the furniture industrial sector a decrease of 0.4% under DR and of 0.2% under S. The effect would remain about 0.4% under DR and 0.2% under S when taking account of 15% efficiency improvements because those effects are too small. Moreover, the effect of complying with the proposed wastewater effluent standards on the total exports of the furniture sector would also be a decrease of 2.5% under DR and of 1.5% under S. However a 15% efficiency improvement would reduce the effect to a reduction of 2.1% under DR and of 1.2% under S. Allowing for price adjustments in the model has not been considered in the analysis because it is not expected that the production of the Gaza Strip would have any effect on the international prices of any of the three industrial products in the international markets.

Finally, the small impact of complying with the proposed wastewater effluent standards at the sectors' level and the absence of data on the initial level of pollution M_0 and the required level of pollution made comparing the government utility of the two policy instruments at present and obtaining the value of subsidies that optimizes the government utility rather difficult processes. However, as the Palestinian Authority will most probably seek foreign support it would be visible to select the value of S according to the amount of funds available to subsidize the new technology. This can be achieved by equating the expected public expenditure $\frac{N\beta S^2}{2\alpha}$ with the total contribution of the government to the industry including the donors support. Moreover, minimizing the impact of complying with the proposed wastewater effluent standards could be achieved not only by applying the subsidies option but also by providing governmental easy loans at least to those firms that have the greatest impact.

CONCLUSION

In the present study, policy analysis on trade and environment relationships as they relate to international competitiveness was conducted using the Larson model and a modified model. The Larson model involves a partial equilibrium model that estimates the percentage change in output and exports caused by some changes in production costs as a result of complying with higher environmental standards related to the industrial wastewater has they been applied. The model was applied to conduct at the firm level analysis of trade and competitiveness and environmental linkages in reference to compliance with industrial wastewater effluent standards, which would result a generic increase in production costs. The model proved to be a very good tool for quantitative policy analysis and can be useful to demonstrate the effect of complying with stringent environmental standards on production and trade for a specific industrial firm. The core issue of the Larson model is to estimate the compliance cost for the firm. The model has been modified in this paper to enable estimating the compliance cost at the sector level by developping a probabilistic model and assuming that the compliance costs of the firms in the sector are independent and identically distributed random variables from the uniform distribution on the interval $[0, \alpha]$. The use of the uniform distribution with a single parameter allows for estimating the sector's compliance costs using the analysis of wastewater samples for a single firm from the sector that can be identified through other measures and avoiding expensive frequent analysis of wastewater samples for many firms. Furthermore, the introduced probabilistic model allows for comparing between two policy instruments that could be applied by the Palestinian Authority and for choosing the optimal policy instrument to apply.

The impact of complying with the proposed wastewater effluent standards on trade and competitiveness of three major industries in the Gaza Strip was investigated at the firm level using the Larson model and at the sector level on two different policy instruments using the modified model. From the above sections the following conclusions can be drawn:

1. Applying the model at the firm level in the Gaza Strip demonstrated that for an average size industrial firm working in any of the three industrial sectors and complying with the proposed wastewater effluent standards

would cause a little decrease in both output and total exports of the company. This impact would be even smaller if we assume that some efficiency improvements would occur to compensate some of the losses of the firms. Similar results were obtained at the sector level when the modified model was applied. The impact of complying with the proposed wastewater effluent standards on each of the three sectors was remarkably smaller than that impact on a single average firm in the sector. These results, which are based on the sector's official data of the year 2000, seem to be encouraging for the Environmental Quality Assurance Authority in the Palestinian Authority.

2. The large difference between the impacts of complying with the proposed wastewater effluent standards at the firm level on the one hand and at the sector level on the other implies that a few large firms are expected to tolerate most of the losses in sector's outputs and exports. This indicates that, if funds are available, the government should limit its subsidies to the large industrial firms in each sector.

3. The proposed effluent standards proved to have some high thresholds that all industrial firms do not exceed. In particular, the thresholds for BOD at 500 mg/l and COD at 2000 mg/l being proposed for adoption by the EQA are quite high as long as municipal wastewater treatment unit is not functioning efficiently. Thus, the model demonstrated that it could be a good scenario-building tool for examining the effect of any proposed environmental standards or policy standards on output and trade as long as the cost of complying with the standards can be estimated.

4. The availability of reliable and detailed data from all the industrial firms in the Gaza Strip, which are not usually published in the required detail, would make the economic model very good quantitative policy analysis and impact analysis tools. Therefore, it is recommended that an environmental database that contains detailed information on all industrial firms should very soon be established.

5. The estimation of the compliance costs for each firm with the environmental standards is at present difficult and very expensive process because the analysis of the wastewater samples are conducted usually in private laboratories. Therefore, for a better use of the model as a quantitative impact analysis tool and minimizing the costs, it is necessary that the EQA should establish a wastewater analysis laboratory.

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