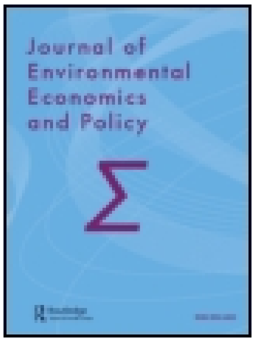

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Tax elasticity of demand for plastic: the cause of plastic pollution in Ghana

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ABSTRACT

Seemingly overlooked causes of inefficiencies in environmental fiscal reforms (EFRs) on plastic waste management are biased tax policies, which include indirect subsidization of plastic waste. With most developing countries grappling with plastic waste, it is paradoxical that they allow considerable tax exemptions on plastics, thereby ignoring the potential environmental damage caused by plastic pollution. This study investigates whether tax elasticity of plastic demand incentivizes unnecessary plastic consumption and subsequently plastic pollution, while accounting for the effect of tax exemptions. First, a simple theoretical model is developed to characterize the tax elasticity of plastic demand. Next, by isolating the attenuating effect of import tax exemptions, both the partial adjustment model and unrestricted error correction model, yield tax-inelastic demand for plastic in the long – and short-run, and speed of adjustments to the long-run equilibrium are estimated at 78% and 88%, respectively. Higher economic activities elicit higher long-run importation of plastic materials, with the effect of environmental tax and exemption being inconsequential. These results emphasize the need for government to embark on extensive restructuring of EFRs to ensure that optimal tax rates are applied on imports and efficient structures of tax exemptions are considered, while tightening possible channels of tax rebating by importers.

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Plastic pollution; tax elasticity; environmental fiscal reform; import tax; environmental tax; import tax exemption

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1. Introduction

The steady increase in global plastic demand and the buildup of plastic waste raise major environmental concerns for policymakers and researchers. As a result, some countries have taken the lead to ban some plastics while others, such as Ghana, explore environmental fiscal reforms (EFRs) including import tax and environmental tax to control unnecessary plastic demand (see Ritch et al. 2009). The EFR describes a range of fees, charges, and levies meant to enforce the environmental agenda while raising government revenue. Unlike the import tax, the environmental tax is meant to internalize the external costs of environmental pollution that were unaccounted for in the consumers' consumption decisions (Poortinga, Whitmarsh, and Suffolk 2013). But, together, both taxes affect market price and can potentially change consumption toward achieving environmental targets in a more efficient and cost-effective way than command-and control-based policies (Chaturvedi et al. 2014). However, a seemingly overlooked aspect in the functioning of the EFR lies in the potential effect of tax elasticity of demand for the synthetic polymer.

Though extensive literature has investigated various plastic taxes or charges, the role of tax elasticity in the functioning of EFR has not been fully explored. The existence of tax exemptions also raises important policy questions in pricing the external cost of plastic pollution. Hence, not

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accounting for the effectiveness of the tax and exemptions in determining the demand elasticity may lead to erroneous conclusions about the effectiveness and efficiency of EFR. Considering that most developing countries are still grappling with plastic waste management, the following specific research questions must be addressed: (1) Are the environmental and import tax imposed on plastic enough to discourage unnecessary demand for plastic? (2) To what extent does the high tax exemption on imported plastic affect the demand for plastic import, while controlling for the effect of economic activities?

The main contribution of this article is to examine how import tax, environmental tax and tax exemption affect the demand for plastic import, while controlling for the effect of economic activities. First, a simple theoretical model is developed to capture and characterize the elasticities through an optimization programme, and secondly, the demand elasticities concerning import tax, environmental tax, tax-exempt and income are estimated using quarterly times series data from Ghana. Since plastic usage in developing countries like Ghana largely comes from importation, the term plastic consumption or demand and plastic import are used interchangeably.

This study stimulates discussions about plastic pollution through the lenses of plastic tax elasticity. In attrition to the literature on demand for plastic, the study compares results using the partial adjustment model (PAM) and the error correction model (ECM). The PAM allows for short-run elasticities to be estimated while the long-run effects are computed through a simple standardization of the short-run parameters using the autoregressive polynomial. The ECM may prove to be superior to the PAM if the variables are cointegrated with short-run dynamics. Despite the appealing nature of the ECM, it does not require pre-testing of unit root and cointegration relationship, which may be questionable. Nonetheless, the ECM approach has gained nobility in the literature. It has been used to measure the income and price elasticities of import (Narayan and Narayan 2005), gasoline, road traffic and road diesel (Basso and Oum 2007; Graham and Glaister 2004; Barla, Gilbert-Gonthier, and Kuelah 2014). Comparing the results from the PAM and ECM, Graham and Glaister (2004) and Basso and Oum (2007) concluded that PAM yields higher elasticities than the ECM, particularly for long-run price elasticity. This study, therefore, estimates the elasticities of EFRs and income using the two approaches. The findings provide empirical evidence to policymakers about the potency of taxation as plastic pollution control measure. The rest of the article is organized as follows: Section 2 presents an overview of EFRs and plastic demand in Ghana. Section 3 presents a brief literature review whereas Section 4 presents the theoretical model. Section 5 describes the empirical model and data, while Section 6 provides the results and discussion. Section 7 concludes.

2. Overview of environmental fiscal reforms and plastic demand in Ghana

Since the introduction of plastic products in the late 1990s to Ghana, the country has seen significant growth in plastic packaging of consumables. Plastic import volumes have since more than doubled. Specifically, the volume of plastic import rose from 19,705,315 in 2004 to 40,425,488 in 2018 (Figure 1). Ghana, generally, imports four plastic types under the HS-codes 3919, 3920, 3923, and 6305. The 3919s are self-adhesive plates, sheets, film, foil, tapes, and strip of plastics. Other plates, sheets, film, foil, tapes, and strip of polymers of ethylene, propylene, styrene, vinyl chloride, polyethylene terephthalate and unsaturated polyesters are coded as 3920. The 3923 represents articles of plastic such as cases, crates, sacks, bags of polymers of ethylene. The most imported, HS-code 6305, are flexible intermediate bulk containers (FIBC) of polyethylene or polypropylene sacks and bags used for packing goods such as sachet water and others.

Despite the overwhelming evidence pointing to marine ecosystem plastic pollution, overfilled landfills, and choked city gutters, the lack of political expediency coupled with ignorance and misperception of the potential hazards of plastic pollution has led to increasing volumes of plastic import. Successive governments have implemented series of policy instruments and interventions such as parliamentary acts and legislations, environmental impact assessments, environmental guidelines, and environmental tax polices (Darimani, Akabzaa, and Attuquayefio 2013; Hilson

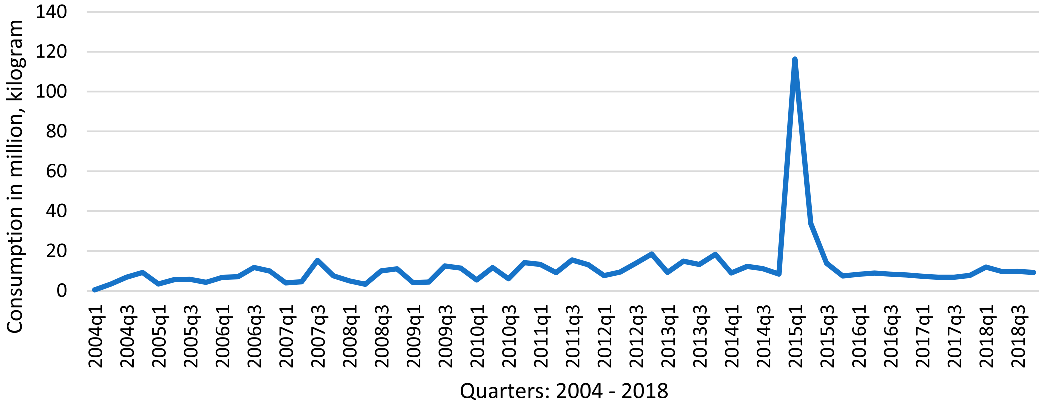

Figure 1. Quantity of plastic import (kilogram): quarterly from 2004–2018.

2004). But no distinct law has been identified for solid waste management, particularly plastic, so inferences are drawn from policy documents such as the National Environmental Sanitation Policy, Guidelines for Landfills/Safe and Sound Management of Bio-Medical Wastes in Ghana, Manual for the Preparation of District Waste Management Plans in Ghana (Asase et al. 2009). Currently, Ghana's EFRs relating to plastic consumption include import tax, import tax exemptions, excise environmental tax and excise environmental tax exemptions as shown in Figures 2 and 3.

Nonetheless, many attempts to deploy these interventions have continuously failed to elicit desired results, in part, due to inefficiencies in implementation (Hilson 2004) and indirect subsidization of waste materials which further reduces the tax elasticity of demand for those plastics. A typical example is the high tax exemption on imported FIBC of polyethylene or polypropylene sacks and bags. Specifically, from 2004 to 2014, import tax exemptions were consistently high, hovering around 37.71% to 39.15% of import values; meanwhile import taxes paid for the same period were evaluated between 2.8% to 9.6% of import value. More than 100% of tax imposed on these large-volume plastics are compensated for by the tax exemptions. It is worth noting that this high-density polyethylene is repurposed to make sachets for packaging water, which is the major contributor of plastic pollution in Ghana. According to GCNET statistics, Government of Ghana had granted about US$1 billion in tax exemption by the close of 2015, of which tax exemption on plastic amounted to

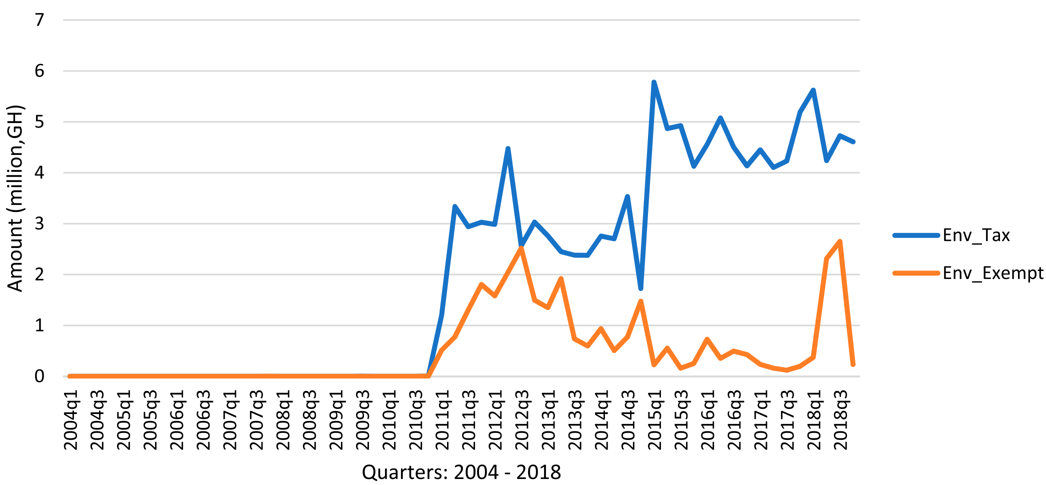

Figure 2. Trends in the average environmental tax and environmental tax exempt.

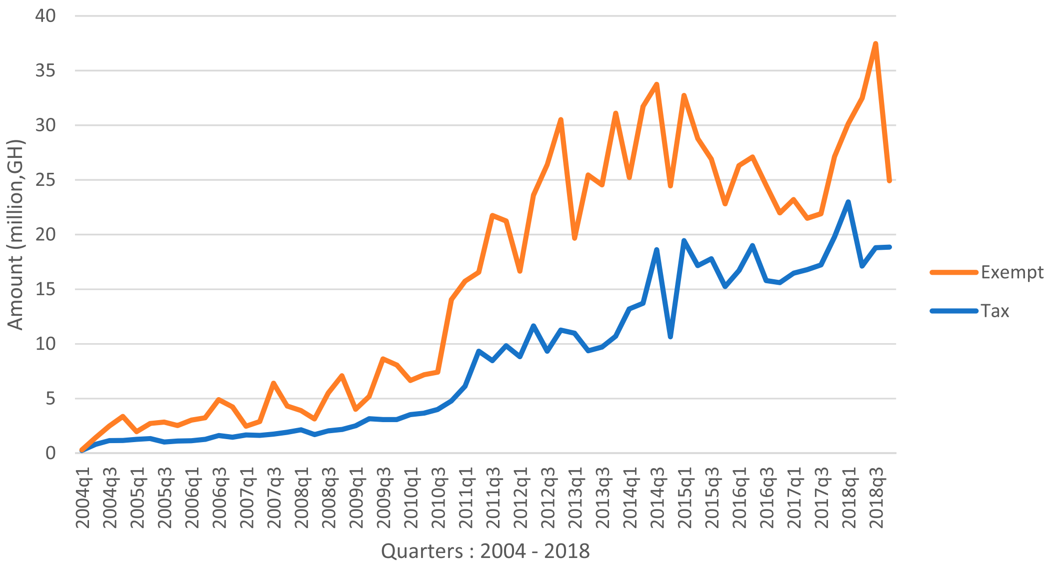

Figure 3. Trends in import tax and tax exemption.

over US$ 10 million (Ghc 41,579,866). Though the government of Ghana currently levies 10% environmental tax (Environmental Excise Tax Act 863) on selected plastic sub-groups, the effective environmental tax on plastic import is less than 10% of import value. The figures for environmental tax are practically negligible (Figure 2). The average environmental tax was 0% of imports in 2006 and increased to 6.91% in 2011 and decreased to 4.66% in 2014. The figure soared to 9.48% in 2015 through to 2017 and fell to 7.7% in 2018.

Currently, Ghana's per capita generation of plastic waste hovers around 0.016–0.035 kg per day and about 89% of plastic waste ends up in the waste streams: of which polyethylene makes up about 70% (Graphic Online 2016). Noteworthy, more than thousand metric tons of finished plastic goods are imported annually. With the cities grappling with waste due to poor management, about 2200 metric tons of waste is generated per day in Accra (Oteng-Ababio 2010). Over US$ 307,340 is spent in transporting solid waste and an extra US$ 163,910 in managing landfill site in Accra per month. The second-largest city, Kumasi, also spent about US$ 491,730 per month to collect and dispose waste (Oteng-Ababio 2011). Despite these efforts, only about 45% of the daily plastic waste generated is collected leaving about 55% in the system (Graphic online 2016). The negative spillovers from plastic use are already apparent in the marine ecosystem and waste streams.

3. Literature review

Since the discovery of plastic in the 1860s, the oil-based material has evolved to include polyethylene terephthalate, high-density polyethylene, polyvinyl chloride, low-density polyethylene, polypropylene, polystyrene or Styrofoam and other miscellaneous plastics comprising acrylic, polycarbonate, acrylonitrile butadiene, polylactide, styrene, fibreglass, and nylon. Polyethylene is the largest globally produced synthetic polymer, with over 100 million metric tons produced annually (Jia et al. 2016). Despite the flexibility and efficiency that plastic offers in packaging and carrying of goods, the increased production and consumption of the synthetic polymer raise major environmental concerns. Currently, polyolefins (high and low-density polyethylene and polypropylene) form more than 60% of plastic content in municipal solid waste (Glaser 2017). Eriksen et al. (2014) estimated that over 250000 metric tons of plastic end up in the ocean. Generally, plastic is harmful to the environment (Otsyina et al. 2018; Fernqvist, Olsson, and Spendrup 2015). It poses both physical and chemical threats to wildlife and marine ecosystems (EPA 2017) as well as the environment because of the lack of low-energy degradation processes, particularly for the polyethylene (see Jia et al. 2016).

Countries throughout the world are waking to the dangers of uncontrolled plastic pollution and are implementing stringent EFRs. In 2003, South Africa passed a legislation making it illegal to use thin and flimsy plastic bags. The effect of the ban on plastic bags in South Africa was dramatic for the first three months before the charge was rescinded. Plastic bag usage reportedly reduced by 70% within the first three months (Dikgang et al. 2012). Throughout West Africa, such plastic ban legislations have received precedence over market-based instruments. Eleven (Togo, Mali, Mauritania, Niger, Senegal, Cote D'ivore, The Gambia, Burkina Faso, Benin, Guinea Bissau and Cape Verde) out of the 16 countries in West Africa, have attempted a partial ban on single-use plastic, with four (Nigeria, Guinea, Liberia and Sierra Leone) remaining indifferent toward either a ban or a market-based approach. However, these bans are in their infancy and are yet to cause such unprecedented shift in consumption as reported by South Africa. It is important to recognize that the partial bans across West Africa are not comprehensive. They are often limited to the production, distribution and consumption of non-biodegradable or lightweight plastic bags (mostly less than 30 μm (micrometer)). This also raises major concern for micro-plastic pollution, particularly for the marine ecosystem.

Wales, the first country in the United Kingdom to introduce market-based reforms, levied a 0.07€ on 'single-use carrier bags in 2011'. The effect of the charge was significant as the use of own bags increased from 62% to 82%, suggesting 20% more reduction in the distribution and use of single-use plastic bags among shoppers in Wales (Poortinga, Whitmarsh, and Suffolk 2013). Convery, McDonnell, and Ferreira (2007) also found evidence of over 90% reduction in plastic bag use in Ireland when the tax was implemented in 2002. He (2010) reported a 49% reduction of plastic bag use in China, in response to the plastic tax introduced in 2008.

Though many studies have provided suggestive pieces of evidence of high tax elasticity of demand for plastic bags, it is worth noting that some authors have questioned the effect of possible omitted variable biases in the ex post facto assessment of the tax effectiveness. It has been argued that the observed impact of plastic tax might be overestimated due to changes in unobserved variables such as societal norms, which are unaccounted for before and after the programme implementation (Rivers, Shenstone-Harris, and Young 2017): a comprehensive review, however, exceeds the scope of this article . Also, other observable variables such as import tax and subsidies may obscure the effect of these market-base tax instruments. It is important to recognize that the effect of these excise plastic taxes may be difficult to measure if we cannot isolate the effect of other enabling variables such as less stringent import taxes and tax exemptions (which function as indirect subsidies) on plastics. This is particularly true for countries who still consider the synthetic polymer an essential raw material in production and packaging of goods. Much of the current literature does not address these cancelling effects of import tax and subsidies in explaining the effect of excise taxes, particularly for plastic consumption. Import taxes and subsidies affect import prices paid by the final consumer and thus the competitiveness of the import product relative to alternative domestic products, which in turn affect import volumes (Kanesathasan 1961). The effects of tax on plastic import is specifically determined by the elasticity of substitution of plastic import for alternative environmentally friendly products and the price elasticity. Suppose domestic prices and foreign supply price of plastic are constant, and the elasticity of substitution is unity, then the import cost will be changed by an amount equal to the total tax exemptions or/and import tax paid. This price substitution effect is likely to be observed without time lags if the demand elasticity of plastic is sensitive to EFRs.

Currently, the fast-growing urbanization and the glowing middle-class pollution in Ghana and the rest of Africa are creating a huge consumer market for plastic packaging and plastic materials. This advancement in economic development is coupled with a disproportionate increase in waste generation and failure to tackle it would expose the environment to degradation (Diaz, Savage, and Eggerth 2005). Hence the need for policy interventions to discourage the use and import of unnecessary plastics. Efficient taxing of plastic would allow for the market to solve the problem of finding the optimal consumption rate.

4. Theoretical model

Once plastic materials are produced, the process is irreversible. It takes an infinite time for them to degrade completely from the ecosystems. If recycling is possible, what it does is to transform the material from one state to the other, thereby postponing the environmental impact. Technological processing cannot wholly destroy the residuals once the material is produced (Ayres and Kneese 1969). By implication, current extraction of plastic equals the amount of waste to be generated in the future Figure 4.

Globally, about 91% of the 8.3 billion plastic produced in the last six decades have not being recycled (National Geographic 2018). Plastic consumption exceeds the recycling rate. If the current rate of use continues, landfill occupancy of plastic waste is estimated to exceed 12 billion metric tons by 2050 (National Geographic 2018). Does tax and exemption on plastic import incentivize unnecessary consumption of plastic in the face of such looming environmental danger? We attempt to answer this question by modelling the tax elasticity of plastic demand as follow:

Suppose that importers pay a per-unit tax T upfront and later apply for a refund on tax-exempt goods.[1] Note that T equals import tax plus environmental tax. Let τ be the rate of tax exemption granted to importers and$P$be the gross price of plastic material after all tax and exemptions are applied. P_a is the unit price of imports, τ functions as a negative tax and lies between zero and one. The gross price monotonically increases in taxes and decreases in tax exemption. Therefore

$$P = (P_a + T)(1 - \tau) \tag{1}$$

Also, assume that importers face a constant marginal cost (C)on importation of (Q)quantity of plastic materials. Since a profit maximizing importer equates its marginal cost to prevailing price of product (i.e. price minus marginal cost) then we maximize the value function V

$$\underset{\{P_a\}}{Max}\ V = (P_a - C)\bullet Q(P(P_a)) \tag{2}$$

which generates the following first-order condition:

$$\frac{\partial V}{\partial P_a} = Q + (P_a - C)\frac{\partial Q}{\partial P}\frac{\partial P}{\partial P_a} = 0 \tag{3}$$

From Equation (3), we obtain (4) by dividing both sides by P_a

$$Q\frac{\partial P}{\partial Q}\bullet\frac{\partial P_a}{\partial P}\bullet\frac{1}{P_a} = -\frac{(P_a - C)}{P_a} \tag{4}$$

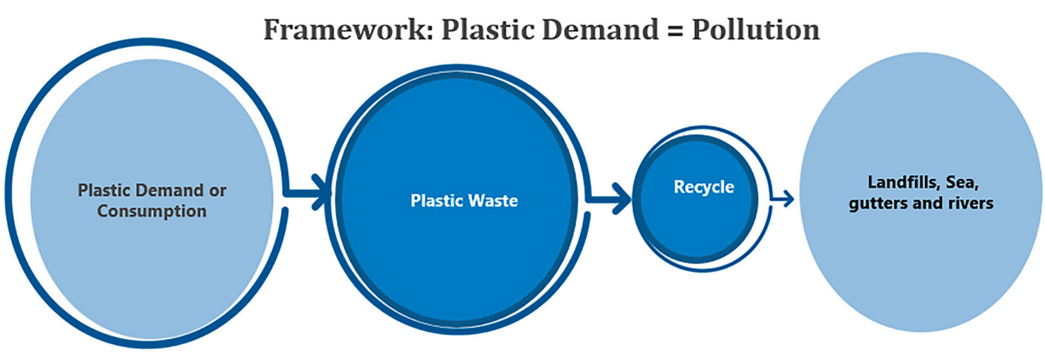

Figure 4. The transition process of plastic consumption into pollution.

Multiplying the right side (4) by $\frac{P}{P}$, we derived

$$\frac{1}{\frac{\partial Q}{\partial P}\frac{P}{Q}\bullet\frac{\partial P}{\partial P_a}\frac{P_a}{P}} = -\frac{P_a - C}{P_a} \tag{5}$$

Let $\lambda = -\left(\frac{\partial Q}{\partial P}\right)\left(\frac{P}{Q}\right)$ be the price elasticity of demand while $\sigma = \left(\frac{\partial P}{\partial P_a}\right)\left(\frac{P_a}{P}\right)$ capture the tax elasticity of the gross price of plastic relative to the importer's net price. Therefore,

$$\frac{1}{\lambda\sigma} = \frac{P_a - C}{P_a} \tag{6}$$

Solving Equation (5) and dividing both side by P, we have

$$\frac{P_a(1-\tau)}{P} = 1 - \frac{T(1-\tau)}{P}, \text{ given that } \frac{\partial P}{\partial P_a} = (1-\tau) \tag{7}$$

$$\sigma = 1 - \frac{T(1-\tau)}{P} \tag{8}$$

From Equation (8), for $1>T>0$ we conclude that $\sigma<1$. Given that the mark-up price over marginal cost is inversely related to $\lambda\sigma$, a value larger than the price elasticity, it presupposes that importers of plastic have a greater power to set the market price above marginal cost. Since gross price increases in import tax and decreases in tax exemption, at higher tax exemptions or lower import tax, demand for plastic will increase. For example, normalizing the average gross price to 1 per unit of plastic and using the figures for Ghana's 2014 import tax and tax exemption to be 24% (0.245) and 26% (0.26) of import values respectively; σ is evaluated at 0.82. The value for the gross price is normalized, so the result should be interpreted with caution. However, it can be concluded that for any rise (fall) in tax exemption (import tax) it follows that tax elasticity (σ) turns to be more inelastic.

5. Empirical model specification and data

The investigation into the tax elasticity of demand for plastic import begins with an estimation of dynamic reduce form model for demand, specifically, a partial adjustment model (PAM) which accounts for the inertia in the reaction of plastic importers. The assumption is that the quantity of plastic imported is affected by exogenous shocks, but the full effect is due to inertia. Quantity of plastic import does not instantaneously respond to changes in the independent variables; it slowly adjusts to the long-run equilibrium. Thus, the latent variable which captures the unobserved desired effects of demand for plastic import at year t is given by:

$$Q_t^* = \alpha_0 + \alpha_1 \log Tax_t + \alpha_2 \log Exempt_t + \alpha_3 \log Env_t + \alpha_4 \log Income_t + \gamma_t \tag{9}$$

where Tax_t is the total import duties. The excise environmental tax paid by importers is isolated as an additional regressor Env_t to capture the direct cost to the environment. $Exempt_t$ is the total tax exemption granted to importers, and $Income_t$ is the income effect proxied with GDP per capita. Note that the per capita GDP is used to control for the effect of economic activities while correcting for the effect of population growth. This model is considered justifiably specified since we failed to establish any significant effects for other potential exogenous factors, including urbanization and industry value-added. Being a staple of modern culture, plastic demand may take time to adjust to long-run equilibriums following shocks. For example, importers' decision to import other plastic types following increase in the tax on 'single used plastics', may take time. This process of adjustment is assumed to take the form:

$$\log Q_t - \log Q_{t-1} = \psi(\log Q_t^* - \log Q_{t-1}) + \mu_t \tag{10}$$

where the actual changes in Q_t is a proportion of the change in Q_t^*which is explained by ψ. Note that Q_t^*equals Q_t in the absence of inertia. And ψ which is the speed of adjustment is assumed to lie $0 < \psi \leq 1$. Substituting (9) into (10) gives rise to the following demand equation:

$$\log Q_t = \alpha_0 + \alpha_1 \psi \log Tax_t + \alpha_2 \psi \log Exempt_t + \alpha_3 \psi \log Env_t + \alpha_4 \psi \log Income_t + (1 - \psi) \log Q_{t-1} + \psi \gamma_t + \mu_t \quad (11)$$

Variables in the model are presented in logarithmic form, suggesting that the coefficients of the choice variables can be directly interpreted as elasticities. The short-run import tax elasticity is, therefore, captured by $\alpha_1 \psi$ and the elasticity of demand for plastic import with respect to tax exemption is $\alpha_2 \psi$. The short-run elasticity with respect to environmental tax is measured with $\alpha_3 \psi$ and the income effect by $\alpha_4 \psi$. In the absence of lags in the long-run adjustment process, short-run parameters will equal long-run parameters. Hence, the long-run elasticities are derived by standardizing the coefficient of the short-run parameter $(\alpha_i \psi)$ by $\frac{1}{\psi}$, where $i = 1, 2, \ldots$. Note that ψ can be obtained directly from the unrestricted estimate of α_i, when the restriction $\alpha_i = (1 - \psi)$ is imposed.

Due to the simplicity of this reduced form equation, it has been largely used in literature for measuring demand elasticities (see Basso and Oum 2007; Barla, Gilbert-Gonthier, and Kuelah 2014). However, if the time series has a unit root, then the results of the PAM may be spurious. Hence the need to further specify the error correction version of the dynamic cointegrating relationship. Pesaran, Shin, and Smith (2001) describe this approach as the autoregressive distributed lags (ARDL). Unlike the conventional cointegration methods, this approach yields consistent and robust estimates for short-run and long-run elasticities for both stationary and integrated parameters. Also, it does not require symmetry of lag length; different variables can be modelled to carry different optimal lags. Most importantly, this approach is relevant for estimating demand for plastic import, in the current study, because it favours small sample size and estimating short – and long-run dynamics without losing long-run information (see Narayan 2006).

The fundamental requirement of the ECM is that a long-run relationship should exist and that strictly exogenous regressors are sufficiently augmented to produce serially uncorrelated residuals. Nonetheless, cointegrating relationships are considered applicable and no prior testing is required to identify whether the regressors are integrated of order one I(1) or 1(0), or a mixture of the two. To clear any ambiguities of spurious correlated regressors and ascertain the cointegrating relationship, Fisher's augmented Dickey-Fuller (in Table 3) and Engle-Granger Augmented Dickey-Fuller test of cointegration or EG-ADF test are performed. The EG-ADF involves a two-stage procedure to estimate the cointegrating coefficient prior to testing for unit root in the error term (Engle and Granger 1987). First, an auxiliary regression model of long run cointegrating relationship (Equation 12) is specified and estimated with the Ordinary Least squares (OLS) estimator.

$$\log Q_t = \varphi_0 + \varphi_1 \log Tax_t + \varphi_2 \log Exempt_t + \varphi_3 \log Income_t + \varphi_4 \log Env_t + \varepsilon_t \quad (12)$$

In second step, if the residuals or error term is nonstationary, then we proceed to estimate the long – and short-run dynamics using the unrestricted Error correction model (ECM):

$$\Delta \log Q_t = \beta_0 + \beta_1 \Delta \log Tax_t + \beta_2 \Delta \log Exempt_t + \beta_3 \Delta \log Env_t + \beta_4 \Delta \log Income_t + \beta_5 \Delta \log Tax_{t-1} + \beta_6 \Delta \log Exempt_{t-1} + \beta_7 \Delta \log Env_{t-1} + \beta_8 \Delta \log Income_{t-1} + \varepsilon_{t-1} + \theta_t \quad (13)$$

where β_0 is the constant term, Δ is the first difference operator and θ_t is the disturbance term. ε_{t-1} is the error correction term. The short-run elasticities are captured by β_1, β_2,β_3 and β_4 and long-run effects are measured by β_5, β_6, β_7, and β_8. Theoretically, since demand decreases in gross price (which increases in import tax and decreases in tax exempt), but rises with income for normal goods, it follows that, all things being equal,β_1, β_3,β_5 and β_7 should be negative whereas β_4 and β_8 as well as β_2 and β_6 are positive. The intuition of a positive income effect is that since plastics are staple for modern consumption behaviour, ultimately, if consumption behaviour is not easily mutable, then large scale economic activities would increase demand for plastic. The tax complementarity effect of EFRs is captured by import tax and environmental tax. Intuitively, given that tax exempt functions as subsidies, the elasticity of plastic demand with respect to tax exempt is expected to be positive.

5.1. Data

The data is sourced from Ghana Community Network Service Limited (GCNET) and the World Development indicator (WDI), spanning from 2004 to 2014. Per capita gross domestic product (GDP) was obtained from WDI. Data on import tax, tax exemption, environmental tax, and quantity (in kilogram) and value of plastic import were sourced from GCNET. The GCNET data is an aggregation of all plastic types imported, namely self-adhesive plates, sheets, film, foil, tapes, and strip of plastics; other plates, sheets, film, foil, tapes, and strip of polymers of ethylene, propylene, styrene, Vinyl Chloride, polyethylene Terephthalate and unsaturated polyesters; cases, crates, sacks, bags of polymers of ethylene and flexible intermediate bulk containers (FIBC) of polyethylene or polypropylene sacks. The author dropped the first quarter of 2015 on suspicion of an entry error in quantity of plastic imported (116345234.17 kg). GDP per capita (current US dollars) was converted to Ghana cedis (GH) to ensure compatibility. Varying the exchange rate does not influence the effect of per capita GDP in the model. The standard deviation, maximum and minimum values indicate that the sample is normally distributed Tables 1 and 2.

6. Empirical results and discussion

To begin with, Fisher's Augmented Dickey-Fuller test is performed to obtain the stationarity of the variables. The results of the test suggest that *Q*, *Exempt*, *Env_Exempt*, *income* are stationary and *Tax*, *Env* are not stationary. By implication, the Ordinary Least Square estimator could produce spurious results. However, I proceed to estimate the partial adjustment model (PAM) since it supports the findings in the Error Correction Model (ECM). The interest of the PAM is to evaluate the serial dependence of quantity of plastic import and the ratio of long-to short-run adjustment to the equilibrium. For comparison with the ECM, the lag lengths are carefully augmented to reflect a consistent optimal lags selection in both specifications using the Akaike Information Criterion (AIC).

Seven different variations of Equation (11) are estimated (in Table 3) using the PAM estimation technique. From PAM 1, 2 and 3, short run *Tax* term hovers around – 0.2 and *Exempt* term is approximately 0.6. These results are consistent with theory, but the effect of inertia appears to be inconsequential in these models. From PAM 1 and PAM 4, the coefficient of *Tax* appears larger when *Exempt* is dropped. By implication, *Exempt* dampens the effect of *Tax*. The attenuating effect of tax exemptions on import tax explains the inelastic nature of import tax elasticity. Thus, the discussion will focus on PAM 7 which isolate the effect of import tax exemption and estimates the elasticity of the other four explanatory variables Table 4.

Table 1. Descriptive statistics (kg/GH).

Variables	Variable definition	Mean (million)	Standard Deviation (million)	Minimum	Maximum (million)
Q	Quantity of Plastic	11.21	14.67	426,671	116.3
Tax	Import Tax Collected	8.550	6.945	243,423	22.99
Exempt	Import Tax Exempted	7.255	5.607	62,729	20.40
Env_Exempt	Environmental Tax Exempt	497349	722962.8	0	2652604
Env	Environmental Tax	1.990	2.058	0	5.780
Income	GDP per Capita (in dollars and not million)	365.5	147.3	100.9	620.2

Table 2. Correlation.

	log Q	log Tax	log Exempt	log Env_Exe	log Env	log Income
log Q	1					
log Tax	0.579***	1				
log Exempt	0.846***	0.851***	1			
log Env_Exempt	0.490***	0.894***	0.798***	1		
log Env	0.527***	0.941***	0.820***	0.957***	1	
log Income	0.558***	0.895***	0.822***	0.796***	0.833***	1

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

Table 3. Time series unit root test.

			Augmented Dickey–Fuller	
Variables	Variable definition	Stationary	Statistics	*P*-Values
Q	Quantity of Plastic Imported	I(0)	−4.743	0.0001
Tax	Import Tax Collected	I(1)	−7.671	0.0000
Exempt	Import Tax Exempted	I(0)	−2.799	0.0035
Env_Exempt	Environmental Tax Exempt	I(0)	−2.812	0.0034
Env	Environmental Tax	I(1)	−6.630	0.0000
Income	GDP per Capita (in dollars and not million)	I(0)	−2.271	0.0135

Table 4. Results of the partial adjustment model.

Variables	PAM 1	PAM 2	PAM 3	PAM 4	PAM 5	PAM 6	PAM 7
Short Run Parameter Estimates							
log import tax	−0.220***	−0.214*	−0.191**	−0.416**		−0.169	−0.426**
	(0.054)	(0.123)	(0.089)	(0.185)		(0.176)	(0.187)
log import tax exempt	0.599***	0.602***	0.606***		0.645***	0.616***	
	(0.054)	(0.070)	(0.057)		(0.071)	(0.081)	
log environmental tax		−0.001		0.073***	−0.025**	−0.004	0.089***
		(0.019)		(0.019)	(0.010)	(0.021)	(0.023)
log income			−0.103	0.262	−0.245	−0.112	0.274
			(0.201)	(0.284)	(0.149)	(0.219)	(0.291)
log environmental tax exempt							−0.016
							(0.017)
Measure of Inertia	0.027	0.026	0.038	0.214**	0.044	0.037	0.216**
	(0.050)	(0.054)	(0.064)	(0.091)	(0.068)	(0.065)	(0.091)
Long Run Parameter Estimates							
log import tax							−0.545**
							(0.225)
log environmental tax exempt							−0.020
							(0.943)
log environmental tax							0.113
							(0.374)
log Income							0.351*
							(0.182)
Constant	9.708***	9.584***	9.562***	16.850***	6.958***	9.162***	16.886***
	(0.721)	(2.001)	(0.949)	(2.409)	(0.865)	(2.544)	(2.447)
Observations	54	54	54	54	54	54	54
R-squared	0.686	0.686	0.688	0.439	0.680	0.688	0.444

Standard errors robust to serial correlation and heteroskedasticity in error terms are in parenthesis. The standard errors for long-run parameters are obtained using the delta method. *** p<0.01, ** p<0.05, * p<0.1

With regards to the effect of the inertia, measured by $(1 - \psi)$, quantity of plastic import is path dependent or autoregressive with the inertia term hovering around – 0.2. The speed of adjustment (ψ) can then be evaluated at 0.78 and the ratio of long-run to short-run effects$(1/\psi)$ is estimated at 1.28. For the case of gasoline and diesel, this ratio ranges from 1.48–6.28 (see Barla et al. 2014; Basso and Oum 2007). As expected, increase in economic activities raises plastic demand, such that a doubling of economic activities results in more than 35% increase in plastic demand. The short-run

Table 5. Results of the error correction models.

Variables	ECM 1			ECM 2			ECM 3		
	Speed of Adjustment	Long Run Coefficients	Short Run Coefficients	Speed of Adjustment	Long Run Coefficients	Short Run Coefficients	Speed of Adjustment	Long Run Coefficients	Short Run Coefficients
log import tax		−0.248***			−0.192			−0.583**	
		(0.088)			(0.173)			(0.252)	
log import tax exempt		0.617***			0.627***				
		(0.089)			(0.104)				
log income		0.017			−0.007			0.489*	
		(0.178)			(0.193)			(0.245)	
Speed of Adjustment	−0.764***			−0.769***			−0.880***		
	(0.116)			(0.119)			(0.103)		
1. D. log tax			0.209			0.200			0.053
			(0.144)			(0.148)			(0.242)
D.log import tax exempt			0.208*			0.198*			
			(0.108)			(0.111)			
D.log income			0.392			0.423			0.020
			(0.468)			(0.492)			(0.810)
log environmental tax					−0.009			0.122**	
					(0.025)			(0.050)	
D.log environmental tax						0.013			−0.009
						(0.017)			(0.034)
log environmental tax exempt								−0.036	
								(0.034)	
D.log environmental tax exempt									0.035
									(0.029)
Constant			7.725***			7.149***			18.755***
			(1.299)			(2.219)			(3.026)
Observations	57	57	57	57	57	57	57	57	57
R-squared	0.888	0.888	0.888	0.889	0.889	0.889	0.698	0.698	0.698

Standard errors in parentheses *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

elasticity of plastic demand with respect to import tax is statistically significant with coefficient −0.43 and the long-run estimate is −0.55. Both elasticities are less than unitary. Thus, a 10% increase in import tax will bring about 4% and 5% decrease in quantity of plastic imported in both the short-run and long-run respectively.

Both short-and long-run elasticities with respect to environmental tax exemption is statistically insignificant. Environmental tax elasticity in the short run is statistically significant with a positive coefficient of 0.09. From data inspection (see Figure 2), both environmental tax and exemption appear to increase very marginally and are not capable of significantly impacting import as shown by the regression estimates.

Next, using the Error Correction model (ECM) three variations of Equation (13) are estimated (see, Table 5). The results are consistent with the estimations from PAMs. Comparing ECM 3 with ECM 1 and 2, it is obvious that long-run effects of *Tax* term has shot up to −0.58 from approximately −0.2 when the *Exempt* term is dropped. This corroborates an earlier supposition that the attenuating effect of tax exemptions may explain the tax insensitive nature of demand for plastic materials. It is, however, apparent that the short-run effects are inconsequential. The discussion herein will focus on ECM 3, which reports R-squared of 0.698. The model appears to be well specified with about 70% of the variations in plastic demand being explained by the tax, exempt, environmental tax and income. The error correction term is very high with a coefficient of – 0.88. The negative serial dependence indicates a reversion to equilibrium after, short-term disequilibrium. This should be expected since plastic importers function as market makers who are involved in the transaction of buying and selling plastic (see Roll 1984). Paradoxically, the short-income elasticity is statistically insignificant, suggesting that impact of economic activities on demand for plastic is inconsequential in the short-run but very important in the long-run (with a statistically significant coefficient of 0.5).

The long-run elasticity with respect to import tax is statistically significant with coefficients of −0.6. This implies that a 10% increase in tax brings about a 6% reduction in plastic imports in the long run. Intuitively, since plastic is wired into the fabric of Ghana's modern culture and used in all aspects of society, from agriculture, construction, industry down to the packaging of fruit and food on the street, it is expected that its demand is more tax inelastic. This can also be attributed, in part, to the lack of cheaper close substitutes and the existence of possible channels for importers to get tax rebates from the final consumer. The short and long-run elasticities with respect to tax exemption are statistically insignificant. As noted earlier, though statistically significant, current effective environmental tax is too small and is unable to elicit significant downward response from plastic demand. Long-run income elasticity is statistically significant with coefficients of 0.49. Thus, a 10% increase in economic activities elicits about 5% increase in plastic import. Considering the widespread usage of plastic in modern culture, it is expected that plastic demand will increase proportionately with economic activities.

Table 6. Summary of elasticities.

Elasticities	PAM	ECM
Import tax		
Short run	−0.426**	0.0527
Long run	−0.545**	−0.583**
Environmental Tax exempt		
Short run	−0.016	0.035
Long run	−0.020	−0.036
Environmental tax		
Short run	0.089***	−0.009
Long run	0.113	0.122**
Income		
Short run	0.274	0.020
Long run	0.351*	0.489*

Robust standard errors in parentheses and *** $p<0.01$, ** $p<0.05$, * $p<0.1$

6.1. Comparative discussion of models

Generally, the PAM models tend to overestimate long-run parameters while the cointegration approach produces a much lower long-run parameter (Basso and Oum 2007; Graham and Glaister 2004). These discrepancies in the parameter estimates can be attributed to the basic assumptions of the two models. Note that the main requirement for estimating the ECM is for the time series to be non-stationary, but this requirement leads to spurious results when using the PAM. Despite the weaknesses of the PAM, the author does not intend to rule out the inferences it provides to the discussion in the current study Table 6.

7. Conclusion

Whether tax imposed on plastic is for environmental reasons or for revenue purposes, it has the potential of changing consumption decisions and subsequently the production of plastic. This could avert the negative spillovers on the environment, marine ecosystem and human health. This study developed a simple theoretical model to characterize the elasticities of environmental fiscal reforms (EFRs) and empirically estimate the elasticities using the PAM and ECM models. Clearly, the results show that import tax exemption, acting as indirect subsidy, significantly dampens the effect of import tax in explaining plastic demand. Import tax exemption paralleled import tax, so much so that a larger positive effect of tax exemption completely cancels out the negative effect of import tax (as shown in ECM 2). Then, by isolating the attenuating effect of import tax exemptions on import tax, both estimation techniques yielded a tax-inelastic demand for plastic materials in both long – and short-run. Higher economic activities elicit higher demand for plastic materials in the long run, but environmental tax marginally increases with demand for the synthetic polymer. Counterintuitively, the effect of environmental tax and environmental tax exemption are inconsequential to explaining the dynamics of demand for the synthetic polymer. This is because environmental tax and environmental tax exemption are practically negligible (see Figure 2) and as such do not significantly impact final prices paid by consumers.

Ceteris paribus, the presence of inefficiencies such as indirect subsidization of environmental damage, in the form of tax exemption, dampens the effect of EFRs regarding pollution control. It is recommended that government embarks on extensive restructuring of the EFRs to ensure that optimal tax rates are applied on import and efficient structures of tax exemptions are considered while tightening possible channels of tax rebating from net buyers. It is also recommended that future studies explore fiscal treatment of the tax by accounting for potential rebate rates being passed on to the consumer, which might explain the inelastic nature of the taxes.

Note

1. In April 2017, Government of Ghana gave directives which require upfront payment of import duty and taxes on imported goods before applying for tax exemptions on exempt goods, due to abuses in the exemption framework. The policy was rescinded in October 2017. Source: Business News of Tuesday, 19 September 2017, citibusinessnews.com.

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