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The Light at the End of the Tunnel: The Impact of Policy on the Global Diffusion of Fluorescent Lamps

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Abstract

The objective of this paper is to study the role of policies in facilitating the diffusion of green innovations, via the import channel, in low and middle-income countries. This paper builds a theoretical framework in which to analyze the role of domestic policies (such as informational campaigns, price subsidies and standards) in encouraging the use of fluorescent lamp (especially CFL) use, while the empirical model also accounts for the role of trade policy instruments and governance. The empirical model uses panel-data from a sample of 73 low and middle-income countries, spanning the period 1993-2013. Initial results suggest that domestic policies pay a pivotal role in facilitating the transfer of CFL, with information provision and subsidies being the most effective policies for this sample. Trade policy instruments, such as trade agreements and tariffs, can also be used effectively to facilitate clean technology diffusion. The nature of the government (autocracies versus democracies) also has an effect on CFL adoption, but the channel through which this effect operates is unclear.

Introduction

It is now widely accepted that policy-makers should formulate climate-change mitigation strategies that encompass a range of policies with the objective of reducing greenhouse gas emissions to meet global obligations (such as those mandated by the Kyoto Protocol in 1997). An important source for achieving these reductions in emissions is improving the energy efficiency of appliances that are used by households, which has the potential not only to lower energy consumption, but also achieve significant cost-savings for households. Energy-efficient lighting is an example of an area where opportunity for these reductions lies. In 2005, lighting accounted for 2650 TWh, or approximately 19% of global electricity use per annum. Artificial light production accounts for 8% of global CO_2 emissions, which is already equivalent to 70% of those from the world passenger vehicles emissions. As the world population, especially in the developing countries, is expected to increase, and as these countries become richer, emissions can only be expected to increase. Improving the energy efficiency of lighting has potential to combat climate-change, at least in the short-run. To this end, there have been significant improvements in lighting technologies in recent times. Energy-efficient compact fluorescent lamps (CFLs) have a particularly high potential to generate residential energy savings, consuming only 20-25% of their energy used by the standard incandescent/ general lighting service (GLS) lamp, for providing the same amount of light. The current technology frontier is represented by the light emitting diodes (LEDs), which are even more energy-efficient.

Incandescent bulbs "produce light when an electric current passes through a filament and causes it to glow", whereas CFL "produce light when an electric arc passes between cathodes to excite mercury and other gases producing radiant energy, which is then converted to visible light by a phosphor coating" (American Lighting Association). Despite several benefits of switching to CFL, their uptake has been limited. CFLs account for only about 6% of the lighting market (IEA 2006). The main hurdle in the way of greater CFL use is the high initial cost of these bulbs compared to incandescent lamps (while these costs have declined, a CFL was almost 20 times more expensive when the technology was new). This has been a significant deterrent towards greater adoption, especially in developing countries. Other reasons for slow uptake include uncertainty about lamp life and quality, and initial issues with performance (such as availability of these lamps only in cooler light colors, and the fact that these bulbs took longer to reach full brightness).

Given the plethora of impediments to their adoption, governments and electric utilities have taken an active role in promoting the adoption of CFLs. On a life-cycle basis, it is cheaper for consumers to purchase CFL rather than incandescent lamps (because of lower energy consumption costs); governments have formulated several forms of market intervention to ensure that consumers have information about these bulbs, and that they make a permanent transition from using incandescent lamps to using CFLs. For instance, many national-level regulatory initiatives are in place to ensure that the incandescent lamps are phasedout. Most OECD countries have banned the production, import and sale of incandescent lamps. While a few developing countries have also followed suit, many are yet to initiate the transition. Both developing and developed countries have also adopted subsidies or giveaway programs for CFL. Governments have instituted minimum energy performance standards (MEPS) for both CFL and incandescent bulbs to restrict the supply of inefficient lamps. Mandatory (and voluntary) energy labeling is another mechanism that policy-makers have used to ensure that consumers are aware of the energy efficiency characteristics of lamps. Given the high mercury content of CFL, a few countries have enacted legislation requiring adequate disposal of CFL. Many utilities, in partnership with local or national governments, have even initiated awareness programs to educate consumers about the benefits of switching to CFLs.

For a developing country looking to switch to clean lighting, the policy-mix available is broad. Most low and middle-income countries are not large producers of CFL, while they do produce incandescent lamps. The notable exceptions are China, which currently produces almost 75% of these lamps, and other countries such as Indonesia, Hungary and Thailand. Therefore, the only way for them to acquire these lamps is via imports, i.e. through international technology diffusion. Trade policy then becomes a natural determinant of greater CFL adoption. Typical instruments of trade policy such as tariffs/duties and trade agreements may have a role to play in facilitating technology transfer. Distance may also play a role as an obstacle to technology diffusion. If the country is far from one of the main exporters of CFL, it may have to put in place additional policies to overcome the barrier of distance.

Given the importance of policies, and thus the state, governance also acquires importance as a factor in influencing clean-lighting technology diffusion. It can be anticipated that there are differences in diffusion rates between autocracies and democracies. Evidence suggest that democracies are more open to trade, facilitate freedom of press, and foster greater public accountability because of the threat of losing power. These strands of reasoning suggest that clean technology adoption, especially through the trade channel, may be more effective in democracies versus autocracies. However, it is not impossible to see why autocracies may be more effective in enforcing regulations such as a ban on incandescent lamps. Cuba provides the perfect example. In 2005, facing an acute energy shortage, the Cuban government was the first one to ban the import and sale of incandescent lamps. Within one year, Cuba had replaced all its incandescent lamps with CFL. The government imported these lamps from China, and provided them to other countries in Latin-America, which also began to enforce a ban on incandescent lamps. Thus, the role of governance on technology diffusion, though critical, is ambiguous.

The objective of this paper is to build a theoretical framework, and also empirically evaluate the effectiveness of different domestic policies on diffusion of CFL, while also accounting for trade policy and governance, i.e. what is the role of domestic policy in encouraging clean technology diffusion? Given that consumers in low and middle-income countries are not only price-sensitive, but also uninformed, should some policies be prioritized over others, at least in the beginning? How important, relatively, are the different policies for this sample of countries? How important are factors such as the effectiveness of the government, the nature of governance, and trade policy in influencing technology diffusion? These questions are relevant for understanding the diffusion of CFL, but are also an attempt to understand, at a broader level, the factors that influence the diffusion of clean technology into developing countries. The structure of the paper is as follows: section 1 provides a literature review, section 2 builds a theoretical framework to answer some of these questions, section 3 explains the data and the methodology used for the empirical analysis, section 4 includes the empirical results, section 5 provides the caveats and policy implications, while section 6 concludes and provides some further avenues for research.

1. Literature Review

This paper can fit into three strands of literature. The first one looks at the role of policy in facilitating clean lighting technology adoption, particularly that of light bulbs. Mills and Schleich (2008) for example looks at the barriers to a household looking to adopt CFL, using German survey data, and finds that these hurdles are weak for most segments of the population, except those households that have a very low income, and these barriers are strongly interrelated to the demographic characteristics of these low-income households, such as small residence size and lack of awareness about clean lighting. Kumar et al (2003) use survey data from India to conclude that awareness about the benefits of CFL is not widespread among consumers. They also find that the biggest hurdles to the adoption of CFL were the high initial price, and the lack of trust in the technology. Alcott and Taubinsky (2014) conduct two randomized control trials in the US, that aim to provide consumers with information about the energy costs of different light bulbs. They find that consumers could benefit from subsidies of the order of those that already exist in certain US states and from performance standards as well, but these are second-best policies. Effective information dissemination remains the most potent policy, however they find no evidence to suggest that a ban on incandescent bulbs could increase social welfare. This paper finds broadly similar results, but differs in the methodology for the empirical analysis: we proxy technology adoption by net imports of CFL, i.e. using trade data. Moreover, the novelty of this paper is that it is the first cross-country study with a focus on low and middle-income countries.

In terms of methodology for the empirical model, Johnstone et al (2008) is relevant. It looks at the effect of environmental policies on innovation in five different renewable energies. They conduct a panel-level analysis, using patent applications as a proxy for innovative activity. The methodology adopted in this paper is similar to theirs: the heterogeneity of the nature, strength and objectives of different policies imply that policy dummies are more effective than continuous variables. Similarly, Bosetti and Verdolini (2013) also use policy dummies to look at the diffusion of both renewable and fossil-fuel based technology in the power sector. They correct for possible endogeneity of the policy instruments by using GMM -estimation, a strategy that is also followed in this paper.

This paper uses net imports to proxy for technology diffusion. There is limited literature on the use of imports as a measure of diffusion. Caselli and Coleman II (2001) use computer imports per worker as a measure of the cross-country diffusion of technology. They justify its use on the grounds that the computer industry is concentrated internationally, with only a few countries providing most of the world's computer output. Technology diffusion in this case takes place through imports of the equipment embodying the technology (we also justify using imports as a proxy for diffusion using the same reasoning). Papageorgiou et al (2006) also uses real imports of medical equipment per capita as a measure of international medical technology diffusion, and evaluate its effect on health status of a sample of countries, and find a positive effect.

This paper is finds place in the broader literature on role of trade in technology diffusion. Coe and Helpman (1995) have looked at the role of trade in determining the total factor productivity of a country, and find that both domestic R&D and R&D of the trading partners affects a country's TFP. Coe et al. (1997) find several advantages of trade for a developing country, in that it can import a larger variety of intermediate goods embodying foreign knowledge, and acquire useful information that is costly to obtain otherwise. Eaton and Kortum (2002) suggests that trade allows a country to benefit from foreign technological advances, but for these benefits to be substantial, the country must be near the source of the advance, and the country needs to be able to reallocate its labor to activities outside manufacturing. Keller (2004) provides a comprehensive review of the literature that considers movement in technology from one country to another via the channel of trade, but mostly for intermediate goods. He suggests that for trade to be an important channel for transfer of technology, it must be the case that technology diffusion be localized, as trade falls with geographic distance. This paper also looks at the role of factors like distance in explaining diffusion, amongst other factors such as participation in trade agreements, tariffs and duties, etc., however finds that their importance depends on the specification used to model the relationship. This paper is also relevant to the literature that looks at the role of trade openness in facilitating technology transfer. For example, Reppelin-Hill (1999) investigates the role of trade openness in the adoption of clean (EAF) steel technology across a sample of countries, and finds that trade openness plays a significant role in the process, i.e. the more open an economy, the faster will be its rate of adoption of this technology.

The final strand of literature looks at the role of governance (in particular, the nature of the government regime) on international trade, and thus on diffusion. Aidt and Gassebner (2010), for example, study the influence of a country's political regime on its bilateral trade flows, and they find that autocracies trade less than democracies, even after controlling for different measures of trade policy and this result is robust. Mansfield et. al. (2000) evaluate the effect of regime type on trade, and reach the conclusion that a pair of democratic countries have more open trade relations than an autocracy and a democracy, although no clear comparison can be made between the openness of trade between a pair of democracies, and between a pair of autocracies. This paper also finds that nature of governance matters, but the channel through which it affects CFL diffusion is not clear.

2.Theoretical Model

2.1 Consumer's problem

The problem of consumers to choose lamps that maximize their utility, and the policy-maker to choose policies that maximize social welfare, is modeled as a two-stage game which is solved by backward induction. This game is played repeatedly, till all consumers switch to CFL use. In the second stage, the decision of a consumer is to choose the quantity of lamps (L) and all other goods (Y), given his budget M and prices P_L and P_Y respectively.

The utility function of the consumer over all goods can be expressed as:

$$U(L,Y) = F(L) + Y \tag{1}$$

where $F(L)$ is an increasing function of L. This utility function is assumed to be quasilinear, given that most consumers only spend a (small) fraction of their income on lamps, and this fraction can be assumed to not change significantly, even when the consumer's income increases. The budget constraint is

$$P_L F(L) + P_Y Y = M \tag{2}$$

where P_L denotes the price vector of lamps, and P_Y denotes the price vector for all other goods. The first -order condition from maximizing (1) with respect to (2) can be expressed as:

$$\frac{F_L}{P_L} = \frac{1}{P_Y} \tag{3}$$

This yields the first proposition:

Proposition 1 *A reduction in P_L (through a subsidy on CFL, for example) will lead to an increase in the number of lamps bought, assuming P_Y and M are fixed. This is similar to a "rebound effect", i.e. consumers will buy more lamps when they become affordable.*

Proof. *This follows from equation (3) above, and the fact that $F(L)$ is increasing in L.* ■

Given the quasilinear nature of the utility function, we assume that the fraction of income the consumer allocates to lamps in the second stage is fixed at M_L. The decision of the consumer, then, becomes to allocate M_L between A (denoting quantity of CFL) and B (quantity of incandescent lamps).

2.2 Preferences Over Uncertainty

The utility that a consumer derives from a lamp is modeled in the Lancasterian preference framework, where consumers have preferences over attributes of goods, rather than the quantities of goods consumed (Lancaster (1966, 1971)). The attribute space over which the representative consumer has preferences is defined by lamp life **V** (given that the demand for lamps is driven mostly by lamp replacements (McKinsey 2012), consumers value lamps having a longer life-span). Other attributes such as brightness, the frequency of flickering etc. are important, but are assumed away in this model for simplicity. Incorporating preferences over these attributes does not alter the main results of the model.

The utility that the consumer derives from V can be represented by a_V, which can be expressed as:

$$a_V = AV_A + BV_B \tag{4}$$

In equation (4), the utility that a consumer derives from lamp life is expressed in terms of the total lamp life from consuming A and B. This equation assumes that consumers have perfect information about lamp life for both CFL and incandescent lamps. However, the lamp life of CFL is modeled as being unknown to consumers (i.e. V_A is unknown and V_B is known). It is reasonable to assume that consumers are imperfectly informed about the product characteristics of CFL, which is a new technology, but they have perfect information about lamp life for the incandescent lamp, which is the prevalent lighting technology in most countries (IEA, 2006).

To explicitly model this uncertainty, an expected utility maximization model is proposed, based on the framework articulated in Roberts and Urban (1988). Let $\widetilde{a_V}$ denote the (uncertain) total lamp life: following Roberts and Urban (1988), we assume an exponential functional form for the utility, which is expressed as

$$U(\widetilde{a_V}) = \exp(-r.a_V(A, B)) \tag{5}$$

where r is the degree of risk aversion of the representative consumer. As in Roberts and Urban (1988), $\widetilde{a_V}$ is assumed to follow the normal distribution, with mean given by

$$\overline{a_V} = A\overline{V_A} + BV_B \tag{6}$$

and variance σ_A^2.The consumer's expected utility from can then be expressed as

$$E(U(\widetilde{a_V})) = \exp\left[-r\left(A\overline{V_A} + BV_B - \frac{r}{2}\sigma_A^2\right)\right] \tag{7}$$

It is assumed that $E_j'(U(\widetilde{a_V})) > 0$ and $E_j''(U(\widetilde{a_V})) < 0$ for $j = A \ and \ B$. The variance associated with the life of a CFL can be expressed as :

$$\sigma_A^2 = \sigma_\mu^2 + \sigma_\epsilon^2 \tag{8}$$

where σ_μ^2 represents uncertainty arising because of information imperfection, and σ_ϵ^2 represents inherent product variability: following (Roberts and Urban (1988)), this is particularly relevant for the CFL market, given that most of these lamps are imported from China, which has come under criticism in recent years for the poor quality of clean lighting that it was exporting to other countries (Lin, 1999). Assume that the prices of A and B are denoted by P_A and P_B respectively. The utility maximization exercise of the consumer can then be written as:

$$Max\ _{A,B}\ E(U(\widetilde{a_V})) = \exp\left[-r\left(A\overline{V_A} + BV_B - \frac{r}{2}\sigma_A^2\right)\right] \text{ subject to} \tag{9}$$

$$P_A A + P_B B = M_L \tag{10}$$

where M_L represents the income the consumer has allocated to lamps. In this second stage of the game, we assume that consumers only choose one variety of lamp, that which yields a higher marginal utility per unit price, i.e. the consumer will choose A over B, iff

$$\frac{MU_A}{P_A} > \frac{MU_B}{P_B} \tag{11}$$

This expression can be re-written as the following:

$$\frac{\overline{V_A} - (rAVar(V_A))}{V_B} > \frac{P_A}{P_B} \tag{12}$$

If this assumption is satisfied, the consumer spends his entire income on A, i.e.

$$A = \frac{M_L}{P_A} \tag{13}$$

and

$$B = 0 \tag{14}$$

2.3 Policy Instruments

Let τ denote a per-unit subsidy on CFL provided by the government. Thus, expression (12) can be modified as

$$\frac{\overline{V_A} - (rAVar(V_A))}{V_B} > \frac{P_A - \tau}{P_B} \tag{15}$$

and expression (13) can be modified as

$$A = \frac{M}{P_A - \tau} \tag{16}$$

We assume that

$$\overline{V_A} = \gamma R \tag{17}$$

where $0 \leq \gamma \leq 1$ represents the probability that the policy-maker implements a regulation/performance standard, and R represents the strength of the standard. R is the life-equivalent of the minimum energy efficiency requirement, which stipulates the minimum life that a lamp should meet. It is not difficult to see that the consumer's belief about the average lamp life would depend (positively) on the strength of the performance standard set by the government. $\overline{V_A}$ is then like the expected life of the lamp. If no such regulation is implemented (with probability $1-\gamma$), the model assumes that the consumer has zero expectation about lamp life, because CFL is a new product with which he is not familiar.

The variance associated with information uncertainty (σ_μ^2) can be expressed as:

$$\begin{aligned} \sigma_\mu^2 &= Var(AV_A + BV_B) \qquad (18) \\ &= A^2 Var(V_A) \text{ (since } V_B \text{ is known and constant)} \\ &= A^2(\alpha - \beta\theta) \end{aligned}$$

where $\alpha, \beta > 0$ and σ_μ^2 depends on parameter θ, which represents the government's credibility in providing information. Consumers need to be informed about the life of CFL (through a label, for example), but they also need to trust the label to reduce variance surrounding lamp life. This trust is positively correlated to the level of government's credibility $g > 0$ (which depends on factors such as regulatory quality, protection of property rights, level of corruption, etc.). The expression for θ can be written as:

$$\theta = \theta(g), \text{where g represents the government credibility in providing information} \qquad (19)$$

(20)

We assume that $\theta' \geq 0$. $\theta = 0$ when no information is provided to the consumer about lamp life (i.e. no energy label is present on the lamp, or no awareness program is in place), whereas $\theta > 0$ otherwise. α is the level of variability when $\theta = 0$. We assume that

$$\alpha = \alpha(D), \alpha' < 0 \tag{21}$$

where D represents the "level" of democracy of the government, i.e. α is higher for more autocratic economies. This can be attributed to the fact that democracies in general are more open than autocracies; even in the complete absence of information about the life of CFL, it is more likely that consumers in democracies are more aware about CFL and its characteristics than in autocracies, which would lower variability surrounding the lamp life. Other factors such as greater public accountability of the government and freedom of press also support this assumption.

2.4 Policy-Maker's Problem

In the first stage of the game, the policy-maker chooses the policy parameters θ, τ and R to maximize social welfare. We assume that these policies are costly, i.e. τ is a per-unit subsidy provided by the government and setting R has a per-unit cost ρ (we assume that ρ is like a cost of enforcement, where imposing a "stronger" standard is more costly for the government to enforce). For information provision, the cost can be represented as $\delta(\theta^* - \theta)$,where δ is the per-unit cost of information provision, and $\theta^*$is the value of θ needed to reduce σ_μ^2 to zero (it is assumed that $\theta \in [0, \theta^*]$).Once the consumer has perfect information about the life of CFL ($\sigma_\mu^2 = 0$), the government no longer needs to incur costs related to information uncertainty, i.e. once $\theta^* = \theta$, $\delta(\theta^* - \theta) = 0$.Let

$$\theta^c = (\theta^* - \theta), \theta^c \geq 0 \tag{22}$$

where

$$\theta^* = \frac{\alpha}{\beta} \tag{23}$$

The policy-maker is cognizant of the damages that B cause to the environment, i.e. aware of the damage function $D(B)$, where we assume that $D(0) = 0, D'(B) > 0$ and $D''(B) > 0$.The social welfare function can then be expressed as:

$$S = E(U(\widetilde{a_V})) - D(B) \tag{24}$$

The budget constraint of the government is

$$\tau A + \theta^c \delta + \rho R = \overline{T} \tag{25}$$

where $\overline{T}$ represents the (per-capita) tax revenue that the policy-maker is willing to spend on policies encouraging consumers to consume A instead of B (assume $\overline{T} \geq M_L$) . The following proposition then follows:

Proposition 2 *The social welfare is higher when B=0, rather than when A=0, i.e.* $S(A = 0) < S(B = 0)$.

Problem 3 Proof. *This follows from the convexity of the damage function D(B).Thus, it is in the policy-maker's interest to choose policies to incentivise consumers to choose A over B in the second stage.* ∎

The problem of the policy-maker becomes to maximize (24) subject to (25), by choosing the policy parameters θ^c, τ and R.We also impose the restriction that expression(15) must hold for the second stage of the game (which follows from proposition 2). If (15) holds, A and B are given by (16) and (14) respectively. Additionally, we impose the inequality given by expression (22). Using Kuhn-Tucker conditions, the problem can be solved to yield the first-order conditions:

$$\tau^E = P_A(\frac{\overline{T} - M_L}{\overline{T} + M_L}) \tag{26}$$

$$\theta^E = \theta^{*,} i.e.\theta^c = 0(from(22) \tag{27}$$

$$R^E = \frac{\overline{T} + M_L}{2\rho} \tag{28}$$

Optimal policy design

At the end of this two-stage game, the policy-maker has chosen optimal levels of the policy instruments to ensure that some consumers have switched to CFL (depending on the total tax revenue available for implementation of these policies). This game is played repeatedly, till all consumers switch to CFL.

- **For new consumers (who haven't used CFL yet):** the policy-maker chooses R^E, θ^E and τ^E to induce them to choose A over B, and then the game is played repeatedly (as follows in the section below).

  The total subsidy bill for the policy-maker to ensure that the representative consumer switches to CFL after the two-stage game is given by

  $$\tau^E * A(\tau^E) = \tau^E * (\frac{M_L}{P_A - \tau^E}) \tag{29}$$

  where τ^E is given by expression (26) above.

- **For consumers who have already used CFL at least once**: the optimal choice of θ^Ein the first stage ensures that information uncertainty is reduced to zero for these consumers, i.e. ($\sigma_\mu^2 = 0$) after the completion of the two-stage game. These consumers are now informed about the average life of a CFL.

Proposition 4 *Once the consumer is perfectly informed about the life of a CFL, he will be indifferent between the two lamps, i.e. CFL and incandescent lamps become perfect substitutes. To then ensure sustained CFL consumption, the government would either need to ensure that borrowing costs are lowered through subsidies, or a ban is imposed on incandescent lamps.*

Proof. Once the consumer is perfectly informed about the life of a CFL, his belief about the average life of a CFL becomes equal to its actual value (μ, say), and information uncertainty (σ_μ^2) is reduced to zero. From expression (9), the utility maximization exercise then becomes

$$Max_{A,B}\ E(U(\widetilde{a_V})) = \exp\left[-r\left(A\mu + BV_B - \frac{r}{2}\sigma_\epsilon^2\right)\right] \text{ subject to} \tag{30}$$

$$(P_A - \tau)A + P_B B = M_L \tag{31}$$

■

It is clear that in this setup, both A and B are equivalent to being perfect substitutes. Thus, the optimal choice of the consumer becomes:

$$\begin{aligned} A \text{ if } \frac{(P_A-\tau)}{P_B} &< \frac{\mu}{V_B} \\ B \text{ if } \frac{(P_A-\tau)}{P_B} &> \frac{\mu}{V_B} \\ \text{Any combination of A and B if } \frac{(P_A-\tau)}{P_B} &= \frac{\mu}{V_B} \end{aligned} \tag{32}$$

The policy-maker has two options:

1) Given that $P_A > P_B$, he will then need to subsidize CFL such that $\frac{P_A-\tau}{P_B} < \frac{\mu}{V_B}$

2) In the absence of a subsidy, or if the subsidy τ is low, $\frac{(P_A-\tau)}{P_B} > \frac{\mu}{V_B}$: the consumer will only buy incandescent lamps. To force him to buy CFL, the policy-maker must ban the use of incandescent lamps, in which case the consumer will be worse off. The policy-maker needs to compensate him to leave him as well off as before.

Proposition 5 *Consumers in autocracies need to be provided more information to switch to CFL than consumers in democracies*

Proof. *This follows from expressions (21) and (27). This implies that in order to incentivise a consumer in an autocracy to switch to CFL, the government needs to provide more information than in a democracy (ceteris paribus).* ■

3.Data and Methodology

3.1 Data

Figure 1 lists the data sources for the variables used in the empirical study. In the absence of data on adoption of CFL for the sample under consideration, trade data is used as a proxy for adoption. The dependent variable is the share of value of net imports of CFL upon the sum of the shares of values of net imports of CFL and of incandescent lamps. Data on trade in lamps is obtained at the HS-6 digit level of classification. The value of net imports was preferred to create the dependent variable, rather than the quantity or weight. There are two main reasons for this. Firstly, the share of net imports of CFL is meant to be a proxy for the level of adoption of these lamps: it is more intuitive to proxy the "consumption" of lamps with value of imports, rather than weight or quantity. Secondly, the value calculation in the UN COMTRADE database takes into account the transport costs associated with the transfer of goods. For instance, the value of exports calculation uses the FOB price, which includes the transaction value of the goods and the value of services performed to deliver goods to the border of the exporting country. Similarly, the value of imports calculation takes into account the CIF-type import price, which includes the transaction value of the goods, the value of services performed to deliver goods to the border of the exporting country and the value of the services performed to deliver the goods from the border of the exporting country to the border of the importing country. The share of net imports is used instead of the share of imports, primarily because the exports of lamps are not zero for many countries in the sample.

Figure 2 gives the list of countries that are included in the analysis. The time period under consideration is 1993-2013.The study focuses on 73 middle and low income countries, for which data on policies was available. Some of the bigger countries which export CFL are excluded from the sample, most notably China, which accounts for almost 65-70% of exports of CFL in recent years. Other exporters such as Hungary, Indonesia and Thailand are also excluded. Additionally, observations for which the ratio of value of net imports to exports is less than 1 are also deleted from the data sample, which implies some observations for countries such as Vietnam, India, Tunisia and Romania are dropped. Thus, the sample is an unbalanced panel. Figure 6 illustrates the trend of the dependent variable over time. It is clear that there is an increase in the share of net CFL over time. Additionally, it is also clear from figure 7 that the share of imports of CFL is consistently higher than the share of exports of CFL, even though both seem to be increasing over time.

Figure 3 presents the summary statistics of the main variables used in the model. The main independent variables of interest are policy dummies for seven different kinds of policies (a ban on incandescent lamps, MEPS, voluntary/mandatory labels, public awareness campaigns, price incentives such as subsidies, and free distribution of CFL). Amongst the main policy variables, it is clear that MEPS and free CFL distribution are most common in this sample of countries. To reduce possible correlations between the main policy variables, the policy dummies are clubbed together into three categories: regulation (includes MEPS and incandescent ban dummies), information (awareness campaigns, mandatory and voluntary labeling schemes) and price incentives (subsidies and free CFL distribution schemes). These dummies are constructed to take the value 1 if there is a policy in that time period, or in the previous time period (to account for delays in the effects of these policies, except for the free CFL distribution variable, in which case the variable at period t takes the value 1 if there's a scheme either in t, or in period t+1).The controls used in the estimations (refer to table 1) mostly account for the effects of trade policy and size of the market.

3.2 Methodology

Two specifications are used to test the propositions of the theoretical model. In the first specification, a fixed-effects panel data model is estimated, using region-by-year fixed effects. This identification strategy is intuitive, given that many countries in the sample are very small to justify using country-level fixed effects. Moreover, there is evidence to believe that there will be significant homogeneity across countries in a region, both in the implementation of policies and their impact on CFL adoption (for instance, several Latin American and Caribbean countries banned the incandescent lamp after Cuba enforced the ban in 2005). Six different regions are considered, based on a geographic classification: Middle-East and North Africa, the Caribbean/Latin America, Central Europe, South Asia, East Asia and Sub-Saharan Africa. Panel-corrected standard error estimates are used, and disturbances are assumed to be heteroskedastic and serially autocorrelated. The model that is estimated using this specification is as follows:

$$NM_{ijt} = D_{it} + T_{it} + G_{it} + D_{it} * G_{it} + X_{it} + \epsilon_{jt} + \mu_{ijt} \; where \tag{33}$$

NM_{ijt} denotes share of net imports of CFL in country i in time t

D_{it} denotes a country-specific policy dummy in time t

T_{it} denotes a country-specific trade policy control in time t

G_{it} denotes a country-specific governance variable in time t

X_{it} denotes a country-specific control in time t

ϵ_{jt} denotes a region-by-year fixed effect

μ_{ijt} denotes a stochastic error term

When estimating this model, it is important to account for possible endogeneity of the policy variables, which could lead to inconsistent estimates if not accounted for. It is quite likely that there is reverse causality in this estimation, i.e. that the policies are a response to the share of net imports of CFL. To reduce the risk of this endogeneity of these variables, the policy dummies are constructed using four lags. The ratio of (MFN) tariffs on CFL and incandescent lamps is also potentially endogenous. Thus, the ratio of one-period lags of these tariffs is used. The results of this estimation are represented in figure 4.

In the second specification, endogeneity is explicitly accounted for. A system-GMM model is estimated (Arellano and Bover (1995), Blundell and Bond (1998)). This method of estimation, which is an improvement over the Arellano-Bond (1991), is useful in estimating models with possible endogeneity and dynamic panels. Additionally, it is particularly appropriate for panels characterized by small T, and large N, and that contain errors that are heteroskedastic and correlated within, but not across countries. A distinct advantage of this technique is that external instrumental variables are not needed to account for endogeneity. In this method, the underlying assumption is that the first differences of the regressors (which are used as instruments for the variables for the equation in levels) are uncorrelated with the unobserved fixed effects. All available lags of the variables, from period t-1 onwards, are used as instruments for the transformed equation. The estimation includes year-fixed effects. The results of this estimation are presented in figure 5. The model estimated is:

$$\begin{aligned} NM_{it} &= x_{it}\beta_1 + w_{it}\beta_2 + u_{it} \text{ for } i = 1, ..., N; t = 1, ..., T, where \quad (34) \\ u_{it} &= v_i + e_{it} \end{aligned}$$

NM_{it} denotes the share of net imports of CFL in country i in year t

v_i denote the county fixed effects

x_{it} denote the strictly exogenous covariates

w_{it} denote the possibly endogenous covariates (and NM_{it-1})

μ_{it} denotes the stochastic error term

4. Results

Figure 4 shows the results from the estimation of the model, using panel-corrected standard error estimates. Region-by-year fixed effects are included in all specifications. The baseline specification is provided in column 1. The results suggest the positive effect of two of the three key policy variables (information and price incentives) on the share of CFL net imports. The coefficient on the information variable is significant at the 1% level, the price incentives variable is significant at the 5% level while the regulation variable is insignificant. The coefficient on the ratio of tariffs on CFL and incandescent lamps has the expected negative sign, while distance (to each of the top 5 CFL exporters in each year multiplied by the share of that country's exports, and then summed) is insignificant. The trade agreement indicator is significant at the 10% level, and has a positive influence on the share of CFL imports, which supports the intuition that trade agreements with the top CFL exporting countries could facilitate the technology transfer. The coefficients of the trade openness measure and the GDP per capita variables are significant at the 5% level, and have negative signs. The intuition is that larger, more open economies would have a lower share of net imports of CFL because these countries are domestic producers of these bulbs, and it is likely that they are exporting these bulbs. Indeed, some of the larger countries in the sample (Brazil, Romania, India and Mexico for example) are CFL producers (and exporters).

The Polity Index is insignificant in column (1). The interaction term between the regulation dummy and the Polity Index is also insignificant in column (2), suggesting that both the incandescent ban, and imposing MEPS (the components of the "regulation" dummy) are not important determinants of the share of CFL diffusion. This is further confirmed by the results in column (5), where the regulation dummy is split into MEPS and incandescent-ban dummies; both the dummies and the interactive terms turn out to be insignificant. Columns (3) and (4) present the estimation results after including interactive terms between the information dummy and the Polity Index, and the price incentives dummy and the Polity Index respectively. The results are broadly similar to those obtained in column (1), other than the fact that introducing the interactive terms renders the main effects insignificant. The role of governance on the share of CFL diffusion in this specification is ambiguous.

While Figure 4 includes results where upto three lags of the key policy variables have been used to minimize the risk of reverse causality, it is not possible to completely rule out the risk of endogeneity. Figure 5 below shows the results of an Arellano-Bover (1995) estimation of the model, which is useful for both eliminating the risk of endogeneity, and uses a dynamic panel technique. The policy variables in these specifications are not lagged, however the lag of the dependent variable is included as a regressor. Time fixed effects are also included. Column (1) presents the results of including the Polity Index as a regressor. Once endogeneity is explicitly accounted for, the results don't change drastically for the policy variables. Information and price incentives still have a positive effect on the share of CFL imports, while regulation is still insignificant. The Polity Index is significant at the 10% level of significance, and has a positive coefficient, suggesting that countries which are more democratic have a higher rate of CFL adoption. All the other controls, however, turn out to be insignificant. In column (2), the regulation dummy is interacted with the Polity Index, however this variable turns out to be insignificant. However, in this specification, the regulation variable is significant, and it has a positive effect on the share of CFL imports. It still holds that more democratic countries have higher adoption rates of CFL. In columns (3) and (4), the information and price incentives dummies are interacted with the Polity index, and these terms are insignificant. Column (5) splits the regulation dummy into its components of MEPS and incandescent ban, and finds that the results are not drastically different from those of column (1), i.e. no aspect of the "regulation" variable seems to affect the share of CFL diffusion. The Sargan test results for all these specifications show that the overidentifying restrictions are valid.

5. Caveats and Policy Implications

There are caveats to the results derived in this paper. Firstly, the theoretical framework does not explicitly model trade in lamps. In that sense, its use is limited to the decisions of policy-makers and consumers once the technology has been already imported. As an extension, the theoretical model will be extended to include the effects of trade policy. Secondly, the empirical model proxies the implementation of policies in the sample of countries by dummies, which circumvents the scale of the programs implemented, or geographical disparities. It also makes it difficult to explicitly account for any lags between the announcement of the policies and their implementation, which may be particularly relevant in case of the ban on incandescent bulbs, for instance. However, there is scant data on the dates of announcement of the incandescent ban for the countries represented in the sample. Mills and Schleich (2013) used German survey data to find that households hoarded incandescent lamps after the announcement of the policy, and before the ban was actually implemented. Such effects cannot be tested with the current data.

The theoretical model does not factor the operating costs of CFL compared to those of incandescent lamps in determining lamp choice for consumers. It assumes after the government has chosen the policy parameters in period 1, the consumer will base his purchase decision only on the initial cost of the lamp, which is higher for CFL than for incandescent lamps (necessitating a subsidy from the policy-maker). However, in reality, the operating costs of CFL are significantly lower than those of incandescent lamps, and a rational consumer would take operating costs into account when making his decision. Incorporating the operating costs into the model would require a dynamic framework, with consumers discounting the future energy consumption costs for both types of lamps. This is relevant, especially as consumers in developed countries, for example, switch from CFL to even more efficient forms of lighting like LED lamps: the operating costs of using LEDs are even lower than CFL. However, an LED is significantly more expensive than even a CFL. Policy-makers would need to either provide them for free, or at a heavily subsidized price in the beginning, to incentivise consumers to use them.

Additionally, proxying CFL diffusion with imports of these lamps (as has been done in the empirical analysis) may also introduce measurement error; while it is true that the major channel for the countries in the sample to acquire lamps is though imports, trade data are often confounded by several factors, and may not accurately reflect the actual imports (for consumption) of CFL in these countries.

Lastly, the paper eschews the production side of the economy, i.e. prices of both CFL and incandescent lamps are taken as a given, and it is expected that firms will be able to meet the demands of the consumers. The lamp industry is an oligopolistic setup, with a few large firms dominating the industry, such as Philips, GE Lighting and Osram. It may be interesting to look at the role of market power in pricing and quantity decisions of firms, and also how the plethora of government policies explored in this paper affect them.

Keeping in mind these caveats, the paper's preliminary results offers interesting policy implications. Both theoretical and empirical results indicate the importance of informational campaigns and price incentives in encouraging CFL adoption: these appear to be the binding constraints in low and middle-income countries. In the theoretical framework adopted in this paper, even the role of regulatory policies such as MEPS is geared towards mitigating uncertainty: standards improve a consumer's belief about the lamp life. Once the consumer is fully informed, the only policies that can motivate consumers to continuously purchase CFL are either long-term subsidies, or banning incandescent lamps. Standards (especially when technology is primarily imported) may be effective in (eventually) facilitating domestic production, and improving product quality, however the greatest barrier to the adoption of a new technology in the beginning is information, and the credibility of the government providing the information; thus policy-makers need to initially prioritize information provision. These results are broadly in line with those found in papers like Kumar et al (2003) and Alcott and Taubinsky (2014). Subsidies are also effective, given the price-sensitivity of consumers when goods are near-substitutes. The empirical results in this paper suggest that regulatory policies (both the MEPS and banning incandescent lamps) do not seem to be influencing CFL adoption. The insignificance of the MEPS variable in the model can be attributed to the strong correlation between informational policies (such as mandatory labeling) and MEPS, which provides further support for the role of standards in reducing informational uncertainty. The insignificance of the incandescent ban dummy in the regressions, however, may be attributed to the fact that very few countries (in this sample) have imposed the ban, and in most cases, quite recently. More data is needed to understand the role of the ban on CFL diffusion. However, the theoretical model predicts that imposing an incandescent ban may actually hurt consumer welfare (even though it will increase CFL adoption) unless consumers are compensated in some other way.

These results are broadly in sync with the existing literature on the use of environmental policies to encourage consumers to switch to cleaner technologies. Coad, de Haan and Woersdorfer (2009), for instance, look at the adoption of green cars in Switzerland, and suggest that the effectiveness of different policies on clean technology adoption depends on how they are combined. In the beginning, policy-makers should provide information to consumers to incentivise consumers who have a more "green" bent of mind to switch to the cleaner technology. However, as time passes, policy-makers might need to introduce low levels of incentives to encourage other consumers to switch to cleaner technologies. This is when financial incentives, or regulatory "sticks" may have a role to play. The results of this paper provide some evidence of this sequence of policy implementation. The theoretical model predicts that even after consumers are perfectly informed, either a ban on incandescent lamps, or subsidies are needed to ensure persistent CFL adoption. The empirical results seem to suggest that this sample of countries are still in an early stage of this sequence of policy implementation, where policies such as the incandescent ban will be ineffective, whereas information dissemination policies (and also price subsidies) are highly effective.

The empirical results also suggest the positive role that trade policy can play in encouraging the adoption of clean technologies. For instance, trade agreements with the top exporters of certain technologies could facilitate technology transfer. Distance is not a deterrent to the transfer of clean technologies, if other policies are in place to encourage the adoption of CFL. Tariffs can also be lowered on clean technology which is primarily transferred through the channel of trade. While this paper does not measure the impact of non-tariff barriers, it supports the hypothesis that trade liberalizing policies such as lowering tariffs on imports of clean technology are measures to encourage greater diffusion.

The impact of governance regimes on clean technology adoption appears ambiguous, as has also been found in the literature. Autocracies have closed-door policies, and don't rely heavily on market-based incentives, but it is not difficult to see why they may enforce regulations (such as a ban on incandescent lamps) more effectively (as the example of the Cuban ban on incandescent lamps suggests). The empirical analysis of this paper suggests that governance affects CFL diffusion, but it does not appear to be the case that autocracies are more effective in enforcing any policies. The logic behind the result that democracies are more likely to adopt CFL is unclear: it is possible that consumers in democracies are more "environmentally-aware" in general, and thus more likely to adopt cleaner technologies, however this hypothesis needs to be confirmed with more data. As the theoretical model predicts, more information is needed in autocracies to encourage consumers to switch to CFL. A closed-door policy may imply that consumers in autocracies are not as well-informed, or even as concerned about environmental policies, as consumers in democracies. Autocracies may then need to implement additional policies to generate environmental-consciousness.

Lastly, the lighting industry has been plagued by quality control issues from the outset, because of poor quality exports of lamps from countries such as China. Governments need to make a coordinated effort to ensure that quality control standards are maintained by firms. As the theoretical model showed, uncertainties about a new technology need to be overcome to encourage adoption. A policy-maker has options to reduce the uncertainty that arises (such as labeling requirements and standards on products), but these options are costly. While requiring manufacturers to follow quality control guidelines is also costly, countries can coordinate among themselves to lower these costs. For example, trade policy instruments such as duties on bulbs of inferior quality can act as an incentive to enforce quality-control. International experience has shown that countries have often resorted to domestic production as a means of mitigating the uncertainty that arises from the imports of poor quality CFL. Countries such as Poland and Hungary have started producing CFL in recent years. This offers another channel through which the government can influence CFL adoption: providing incentives to domestic firms to turn producers of these lamps. While this paper does not explore this channel, it is clear the richer, more open economies in the sample are actually net exporters of CFL.

6. Conclusion and Further Avenues for Research

The objective of this paper was to evaluate the effectiveness of different types of policies in influencing the diffusion of clean lighting (CFL) to low and middle-income countries, which are not large producers of these lamps. The main results of this paper are that for consumers that are new to a certain technology, the provision of information and price subsidies is important. Policies such as banning the use of incandescent lamps may leave consumers worse off, unless they are compensated otherwise. Regulations such as MEPS also play the role of mitigating uncertainty, but they may be more effective in richer countries (imposing MEPS in higher-income countries may limit the imports of poor-quality lamps, forcing domestic producers to switch to domestic production to meet stringent domestic standards). Trade policy is also very important, and could be an effective tool in encouraging technology transfer when trade is the main channel for technology diffusion. The role of governance is not clear from these results, but more democratic countries seem to be adopting CFL more than autocratic ones. This may be attributed to higher levels of general environmental awareness in these countries, which also happen to be more open to trade. This paper raises several interesting avenues for further research. One possible extension would be to look at the role of a "policy leader" in influencing the adoption of policies in other countries (for instance, the role of Cuba in influencing other Latin American countries to impose an incandescent ban). Another extension would be to explicitly model the difference in policy regimes between autocracies and democracies, and evaluate how governments affect technology adoption through adoption of different policies. Another factor this paper does not consider is the important of product quality, which is a fruitful extension, given that lamp quality has been a serious concern. More data would be required to study these questions.

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Figure 1: Data Sources of the Modeling Variables

Variable	Data Source
Dependent Variable (share of CFL net imports)	UN COMTRADE Database
Incandescent Ban	UNEP en.lighten Country Lighting Assessments/ other country-level reports
MEPS	UNEP en.lighten Country Lighting Assessments/ other country-level reports
Voluntary Labels	UNEP en.lighten Country Lighting Assessments/ other country-level reports
Awareness Programs	UNEP en.lighten Country Lighting Assessments/ other country-level reports
Free CFL Distribution	UNEP en.lighten Country Lighting Assessments/ other country-level reports
Price Incentives	UNEP en.lighten Country Lighting Assessments/ other country-level reports
Ratio of Tariffs on CFL to Tariffs on IB	WITS (TRAINS) Tariff Data
Trade to GDP	World Bank Database
Trade Agreement Indicator	De Sousa, J.(2012) , " The currency union effect on trade is decreasing over time", Economic Letters, 117(3), 917-920
Distance times the share of CFL exports of the 5 largest exporters	CEPII Database; UN COMTRADE
Polity Index	Polity IV Dataset
GDP Per Capita	World Bank Database

Figure 2: List of Countries Included in the Sample

Countries Included in the Sample					
Albania	Costa Rica	Guatemala	Madagascar	Pakistan	Suriname
Argentina	Cote d'Ivoire	Guinea-Bissau	Malawi	Panama	Swaziland
Bangladesh	Cuba	Guyana	Malaysia	Peru	Tajikistan
Belarus	Zaire	Haiti	Mali	Philippines	Timor-Leste
Belize	Dominica	Honduras	Mauritius	Romania	Togo
Benin	Dominican Republic	India	Mexico	Rwanda	Tunisia
Bolivia	Egypt	Iran	Morocco	Saint Lucia	Turkey
Brazil	El Salvador	Jamaica	Mozambique	Senegal	Uganda
Bulgaria	Ecuador	Jordan	Namibia	Seychelles	Ukraine
Cape Verde	Ethiopia	Kazakhastan	Nepal	South Africa	Venezuela
Central African Republic	Gambia	Kenya	Nicaragua	Sri Lanka	Vietnam
Colombia	Ghana	Lebanon	Nigeria	Sudan	Zambia
Zimbabwe					

Figure 3: Summary Statistics

Summary Statistics						
Variable	**N**	**Mean**	**Std. Dev**	**Min**	**Max**	**Missing**
Incandescent Ban	1488	0.05	0.22	0	1	0
MEPS	1488	0.17	0.38	0	1	0
REGULATION	1488	0.16	0.37	0	1	0
Labelling (Mandatory/Voluntary)	1488	0.08	0.28	0	1	0
Awareness Programs	1488	0.13	0.33	0	1	0
INFORMATION	1488	0.24	0.43	0	1	0
Free CFL Distribution	1488	0.17	0.38	0	1	0
Subsidies/Rebates	1488	0.11	0.32	0	1	0
PRICE INCENTIVES	1488	0.26	0.44	0	1	0
Trade to GDP	1416	75.1	38.26	11	254.606	72
Trade Agreement Indicator	1488	0.14	0.35	0	1	0
GDP Per Capita	1448	2297.82	2248.23	122	4235.84	40
Distance times the share of CFL exports of the 5 largest exporters	1488	5864.615	2471.08	1328.43	14500.11	0
Polity Index	1378	3.263425	5.63	-9	10	110

Figure 4: Results of Fixed-Effects Estimation (using panel-corrected standard errors). Standard errors are given in parentheses below the coefficients. *,** and *** denote 10%, 5% and 1% levels of significance respectively.

Ratio of Net imports of CFL to Sum of Net imports of CFL and Net Imports of IB	1	2	3	4	5
Regulation	-6.24	-6.41	-5.33	-4.54	
	(16.61)	(31.56)	(5.88)	(16.18)	
Information	36.39***	29.70*	29.34	31.48*	33.96*
	(19.54)	(18.36)	(25.83)	(18.30)	(19.90)
Price Incentives	42.25**	39.33***	36.60***	22.9	44.14***
	(16.65)	(15.12)	(14.78)	(20.32)	(16.05)
Ratio of Tariff on CFL to tariff on incandescent bulbs	-28.78***	-33.23***	-29.25***	-29.46***	-30.43***
	(11.04)	(11.16)	(10.88)	(10.23)	(11.55)
GDP Per capita	-0.02**	-0.02***	-0.02***	-0.02**	-0.02**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Trade Agreement Indicator	44.93*	52.60**	49.98**	47.98**	48.01
	(26.90)	(27.44)	(25.05)	(24.25)	(30.06)
Distance times the share of CFL exports of top 5 exporters	-0.01	-0.01	-0.01	-0.01	-0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Trade to GDP ratio (Trade openness)	-0.87**	-0.86	-0.79**	-0.72**	-0.91**
	(0.38)	(0.42)	(0.38)	(0.35)	(0.45)
Polity Index	1.99	2.25	1.71	0.63	2.78
	(2.16)	(2.38)	(2.17)	(2.27)	(2.30)
Regulation interacted with Polity Index		-0.31			
		(4.33)			
Information interacted with Polity Index			0.22		
			(3.67)		
Price Incentives interacted with Polity Index				3.71	
				(2.71)	
MEPS					-2.46
					(38.3)
Incandescent Ban					-2.67
					(26.40)
MEPS Interacted with Polity Index					-0.76
					(5.07)
Incandescent Ban interacted with Polity Index					-0.27
					(3)
Number of Observations	519	519	519	519	519
Region-by-year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Wald chi2	164.47	180.16	624.02	621.26	174.48
(Prob > chi2)	0.0003	0	0	0	0

Figure 5: Results of System-GMM Estimation (using a dynamic panel). Standard errors are given in parentheses below the coefficients. *, **, *** denote 10%, 5% and 1% levels of significance respectively.

Ratio of Net imports of CFL to Sum of Net imports of CFL and Net Imports of IB	1	2	3	4	5
Lag of dependent variable	0.15*** (0.03)	0.16*** (0.04)	0.16*** (0.04)	0.16*** (0.04)	0.16*** (0.04)
Regulation	35.43 (32.72)	50.30* (28.48)	40.8 (31.60)	38.62 (33.51)	
Information	34.12** (17.33)	32.80** (15.80)	29.68* (17.46)	28.29* (16.03)	28.86** (14.44)
Price Incentives	43.67** (17.80)	37.71** (18.61)	39.30** (17.49)	25.19* (13.55)	39.15** (19.47)
Ratio of Tariff on CFL to tariff on incandescent bulbs	-12.32 (12.56)	-11.37 (12.58)	-9.46 (11.15)	-7.25 (11.43)	-9.44 (11.57)
GDP Per capita	-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)
Trade Agreement Indicator	39.95 (33.16)	43.40 (31.08)	39.94 (32.23)	35.68 (31.58)	39.13 (28.73)
Distance times the share of CFL exports of top 5 exporters	-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)
Trade to GDP ratio (Trade openness)	0.06 (0.13)	-0.01 (0.10)	0.03 (0.12)	0.05 (0.12)	0.00 (0.10)
Polity Index	2.80* (1.66)	2.80** (1.42)	2.41 (1.58)	1.24 (1.25)	2.61* (1.41)
Regulation interacted with Polity Index		-2.28 (3.07)			
Information interacted with Polity Index			-0.05 (2.14)		
Price incentives interacted with Polity Index				2.17 (1.58)	
MEPS					45.06 (28.09)
Incandescent Ban					8.67 (14.66)
MEPS interacted with Polity Index					-1.03 (4.46)
Incandescent Ban interacted with Polity Index					-4.67 (5.90)
Observations	486	486	486	486	486
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
F-statistic	100.54	108.5	105.44	107.02	103.01
(Prob > F)	0	0	0	0	0
Sargan test	0.984	0.991	0.992	0.992	0.992

Figure 6: Average of Share of Net Imports of CFL (measured in value terms, averaged across countries)

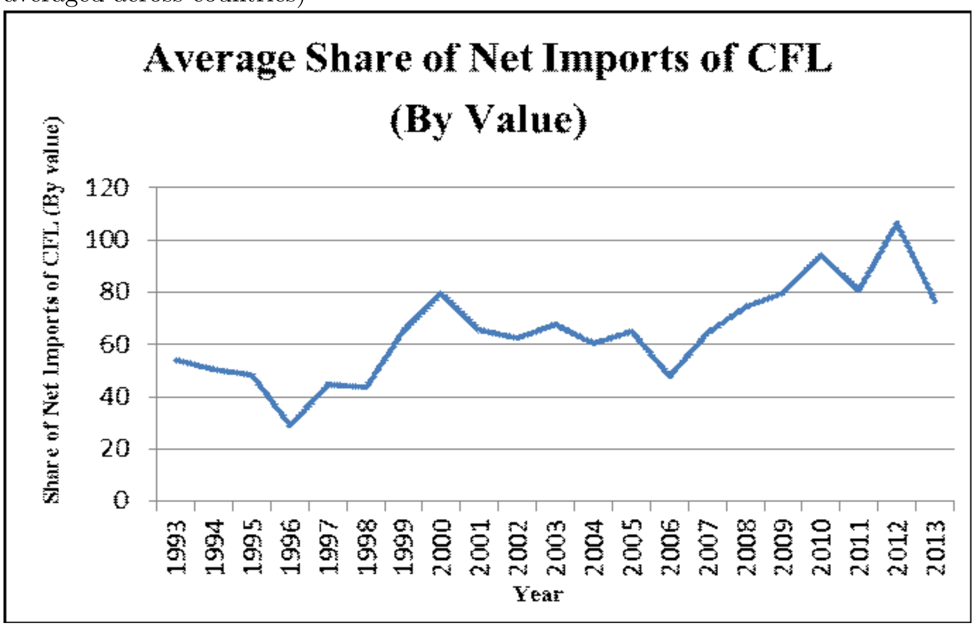

Figure 7: Average of Shares of Imports and Exports of CFL (measured in value terms, averaged across countries)