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The Environmental Goods Agreement:

How Would US Households Fare?

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ICTSD

International Centre for Trade
and Sustainable Development

Policy Brief

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ICTSD welcomes feedback on this publication. This can be sent to Ingrid Jegou (ijegou@ictsd.ch) or Fabrice Lehmann, ICTSD Executive Editor (flehmann@ictsd.ch).

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LIST OF ABBREVIATIONS

CE	Consumer Expenditure
CFL	compact fluorescent lamp
EGA	Environmental Goods Agreement
GDP	gross domestic product
HTS	Harmonized Tariff Schedule
ICTSD	International Centre for Trade and Sustainable Development
LED	light emitting diode
MFN	most favoured nation
MSA	metropolitan statistical area
SCWF	solar control window films
UCC	Universal Classification Code
USITC	United States International Trade Commission
USTR	United States Trade Representative
WTO	World Trade Organization

FOREWORD

In 2014, a number of WTO members launched negotiations of an Environmental Goods Agreement (EGA). The agreement is intended to reduce tariffs on a list of environmental goods by the signatories, after which the tariff concessions would be extended to all WTO members based on the most-favoured-nation principle. A successful conclusion of the EGA negotiations would be a first step towards binding tariff concessions at the international level, complementing efforts like those by the Asia Pacific Economic Cooperation (APEC) economies, which are non-binding, or regional and bilateral efforts in preferential trade agreements. Not only would a reduction in tariffs improve market access and therefore lower the costs of environmental goods, but it would also lay a foundation on which to build.

For many of the goods discussed under the EGA, tariffs are already very low, to a great extent thanks to previous concessions under the WTO's Information Technology Agreement (ITA). However, for other key environmental goods, such as in the wind industry sector, tariff reductions under the EGA would make a difference. Moreover, since many environmental goods are produced in global value chains, where sometimes thousands of different components cross international borders before final assembly, even small tariff reductions may add up to significant gains for end producers.

While the main objective for reducing tariffs on environmental goods in an accelerated manner is driven primarily by environmental concerns, including the pressing challenge of climate change, it also makes good economic sense. It can stimulate the growth of the green industry in EGA countries as well as in those who don't actively participate but who will nevertheless benefit from the improved market access. Reducing costs of clean energy technologies worldwide may also facilitate access to electricity, thereby powering growth even in remote areas.

Another less frequently discussed benefit is reduced consumer prices for environmental goods, even in industrial economies. Moreover, EGA tariff elimination can spur demand for energy efficient goods, which in turn results in energy savings and therefore lower running costs in connection with operating these goods.

This paper, using econometric models, looks into the case of possible consumer benefits in the United States of the EGA. It estimates both the price effects of the tariff reductions under the EGA and the volume effects, and corresponding energy cost savings that occur as consumers switch to more energy-efficient products. The authors are Christine McDaniel and Kornel Mahlstein from the renowned global law firm Sidley Austin. Christine is a Senior Economist in Sidley's Washington, D.C. office, and a member of the firm's International Trade and Dispute Resolution and Antitrust/ Competition practice teams. Kornel is is an Economist in Sidley's Geneva office, where he provides analytical and econometrical assistance to companies, associations and governments on international economic, trade and competition policy issues.

Produced by the Climate and Energy Programme of ICTSD, we are confident that the paper will be useful in informing trade negotiators and policymakers in the EGA countries by adding another dimension of analysis of the EGA. It will also benefit a broader range of countries who are pondering whether to join the effort. Ultimately, a broader participation in the EGA will help fulfil several of the Sustainable Development Goals as well as the Paris Agreement on Climate Change.

Ricardo Meléndez-Ortiz
Chief Executive, ICTSD

EXECUTIVE SUMMARY

We examine household-level effects of the World Trade Organization (WTO) Environmental Goods Agreement (EGA) that aims to eliminate tariffs on a range of environmentally friendly goods. Tariff elimination can result in lower consumer prices and therefore lower acquisition costs for US households. In addition to that price effect, there is a beneficial volume effect at work: EGA tariff elimination can spur demand for energy-efficient goods, which in turn results in energy savings and therefore lower running costs in connection with operating these goods.

We focus on the consumer surplus effects for a set of products that are being considered for inclusion in the agreement. We utilise the Consumer Expenditure Survey (U.S. Bureau of Labor Statistics 2015) and exploit the heterogeneity in consumer spending patterns across different household types. We estimate two household-level effects. First, we estimate the price effect, as declining prices bring lower acquisition costs on quantities already purchased, and households experience increased disposable income. Second, we estimate the volume effects and corresponding energy cost savings that accrue as a result of consumers substituting energy-intensive for energy-efficient products, and benefitting from lower operating or running costs.

Key Findings

US households will benefit from tariff cuts through lower acquisition costs for environmental products covered by the EGA:

- Total US household savings from EGA tariff cuts are approximately US$845 million per year. Most of the savings are related to bicycles and energy-efficient light bulbs.
- Lower-income households will benefit disproportionally, which reflects the larger share of income spent on products covered by the EGA.

Assuming that US consumers will increasingly substitute for cheaper EGA goods, households will benefit each year from lower energy bills and greater energy efficiency:

- The tariff reduction on solar control window films will help 15,000 to 30,000 US households save 4.8 percent to 9.9 percent on their electricity bills each year.
- The tariff reduction on LED and CFL bulbs will save US households US$129.6 million on electric bills each year.
- Greater usage of energy-efficient bulbs is estimated to save 238 million kilowatt hours in the United States each year. These savings correspond to 124,000 tons of coal each year.

Consumer survey data reveal non-trivial differences in household expenditure patterns, and we focus on geographic region, urban, or rural location, size of household, income, and homeowner or renter status. We find that expected benefits from the EGA tariff cuts would be distributed heterogeneously among different socio-demographic and geographic groups.

Our results suggest that estimated total household savings from EGA tariff cuts overall (price effects) are roughly US$845 million per year. We find the savings will disproportionally benefit lower-income households as these households spend a larger share of their income on products covered by the agreement.

In terms of volume effects and the energy cost savings that ensue, we find that greater usage of solar control window films is estimated to help 12,000 to 24,000 US households save 4.8 percent to 9.9 percent on their electricity bills each year. Also, greater dissemination of light emitting diode (LED) and compact fluorescent lamp (CFL) bulbs could save US households US$129.6 million on electricity bills each year. Greater usage of energy-efficient bulbs is estimated to save 238 million kilowatt hours, which is equivalent to 124,000 tons of coal each year. To put this figure in context, the U.S. Energy Information Administration reported that in 2015 the State of Maine consumed 104,000 tons of coal and the State of New York consumed 1.76 million tons.

Researchers may find household-level analysis, such as that presented here, to be a useful complement to economy-wide analysis such as computable general equilibrium modelling, particularly when trying to understand potential distributional effects of trade policy.

1. INTRODUCTION

Negotiations on the plurilateral World Trade Organization (WTO) Environmental Goods Agreement (EGA) were launched in July 2014 and are set to eliminate tariffs on a range of products related to environmental protection and climate change mitigation, including products used for generation of renewable energy, control of air pollution, waste management, water treatment, noise abatement, and environmental monitoring and analysis. The group of negotiating member countries includes Australia, Canada, China, Costa Rica, the European Union, Hong Kong, Iceland, Israel, Japan, Korea, New Zealand, Norway, Singapore, Switzerland, Chinese Taipei, Turkey, and the United States, which together account for approximately 90 percent of global exports in environmental goods.[1] Initially, member countries aimed to conclude negotiations by December 2016. The ministerial-level meeting in December 2016, however, finished without agreement, leaving next steps unclear for the time being.[2]

The rationale for the agreement can be seen clearly in this statement by the United States Trade Representative (USTR):

> By cutting tariffs on environmental goods, we can improve access to the technologies that the United States and other countries need to protect our environment, thus lowering the costs of environmental protection, while unlocking opportunity for U.S. exporters and spurring innovation in green technologies. (USTR 2014)

There are surprisingly few empirical studies of this agreement. That may in part reflect the relatively non-controversial nature of cutting tariffs on environmental goods and/or the relatively narrow product scope and also the fact that the complete list of goods to be included in the EGA is not yet known. The available institutional work on the EGA is largely qualitative in nature. The World Bank has discussed the potential economic and environmental benefits of the EGA (McKenna, De Melo, and Vijil 2014). The International Institute for Sustainable Development of the Inter-American Development Bank has considered the implications for Latin America and the Caribbean (Cosbey 2014), generally finding positive effects. Both institutions note that the benefits could be even greater with an expanded list of environmental goods and services and inclusion of non-tariff barriers.[3] A paper by Monica Araya (2016) looks at the EGA through the lense of a developing country. While the objective of the EGA is to facilitate the dissemination of environmental technologies and make them more accessible, in particular in developing countries, many developing countries have chosen not to join. Her research suggests the EGA could lower the cost and enhance the supply of clean energy and energy-efficiency technologies. However, the narrow focus on tariffs and the exclusion of environmental services limits its impact.

We were only able to find a single empirical study dealing with the EGA. A paper published by Trade Partnership Worldwide estimated the effects on the Chinese economy in terms of gross domestic product (GDP) and considers environmental health and social benefits. Using an industry-focused, globally linked partial equilibrium model, the study finds economic benefits in terms of higher GDP numbers and significant health benefits from improved environmental conditions (Trade Partnership Worldwide 2016).

Studies of trade policy that centre around economy-wide effects capture the overall net effect on the average "representative"

1 See WTO (2016) and USTR (2016).

2 For more details see ICTSD (2016).

3 The Office of the United States Trade Representative formally requested that the United States International Trade Commission (USITC) provide a (confidential) report on the probable economic effects of removing duties on environmental goods (USITC 2015).

household. However, the Consumer Expenditure Survey (CE), conducted by the United States Census Bureau for the Bureau of Labor Statistics (2015), reveals non-trivial differences in expenditure patterns across a number of household characteristics. Thus, this study sets out to quantify the increase in disposable income (a price effect) experienced by US households of different demography, geography, and income level that results from the tariff elimination and lower prices encapsulated in the EGA. In addition, we consider the energy cost savings effect brought about by the EGA. That is, the decrease in prices of environmental goods will lead to an increase in quantity demanded (volume effect) and facilitate increased energy savings for US households, such as reduced utility bills, as well as beneficial environmental effects.

Household characteristics in our study include geography (regions of the United States, and urban or rural), size of household, income, and homeowner or renter status. While a number of goods included in the EGA are generally intermediate goods and not designed for private use, there are several goods that are purchased directly by consumers. We focus our analysis on goods that are part of a common household basket. We base our analysis on the following products that are being considered for inclusion in this agreement: light emitting diode (LED) lamp fittings, compact fluorescent lamp (CFL) bulbs, bicycles, solar control window films (SCWFs), and a variety of "smart" and energy-efficient products for the home, such as automatic thermostats, water meters, electricity meters, gas meters, gas detectors, and motion sensors.

The remainder of this paper proceeds as follows. The next section discusses the empirical model we applied to determine the benefits of the EGA to different groups of US households. Section 3 discusses data sources and section 4 describes the implementation strategy. Section 5 discusses the results for various goods and household types. Section 6 concludes. Appendix A provides details of our calculations.

2. THE MODEL

Our model is motivated by Nicita, Olarreaga, and Porto (2014), in which the authors offer a household model linking trade policy to household welfare and use a household model to examine the existing structure of protection in Sub-Saharan African countries. Appendix B includes the original model set-up in its entirety.

For the purposes of this study, we use a simplified version of the household production model in Nicita, Olarreaga, and Porto (2014). We focus on the consumer surplus effect (and disregard the producer surplus effect for the sake of this exercise) and concentrate on the impact of a price change on household expenditures. As prices go down consumers are better off because their real income increases. With the household as the basic unit of analysis, the model allows us to report results on a highly disaggregated level, broken down by geographic or socio-demographic subgroups. Our analytical approach is encapsulated in equation (1), which describes how price changes induced by tariff cuts affect the income and purchasing power of households as the prices of goods change.

(1) $$d\tilde{y}_j^g = exp_j^g \, dp^g ,$$

Where:

$d\tilde{y}_j^g$ measures the change in income of household *j* per consumption good *g* as a result of lower tariffs and therefore lower prices afforded by the conclusion of the EGA;

exp_j^g denotes the expenditure share of good g in the consumption bundle of household *j*; and

dp^g denotes the change in the price of good *g* as a result of lower tariffs.

Our starting point is the change in price resulting from tariff elimination. We hold wages and the composition of consumption baskets constant, and estimate the change in household income in terms of household expenditures and price changes. The variation in household spending patterns suggests that some households will experience greater cost savings than others. For instance, in absolute terms, urban households may spend more on bicycles than rural households; as bicycle prices decrease, urban households may then realise greater cost savings as compared to rural counterparts, holding wages and consumption constant.[4] In relative terms, the households that spend a greater share of income on goods that are decreasing in price would be expected to experience a greater impact on income from the price change afforded by the conclusion of the EGA.

4 The price effect we estimate is close in nature to equivalent variation, which is a simple measure of economic welfare associated with a change in prices. See Hicks (1941, 1943). Specifically, it is the monetary measure of how much better off a household would be because of the price change while holding wages and the composition of household consumption baskets constant.

3. IMPLEMENTATION

3.1 Price Effects

This section explains how we estimate the price effects for household *h* income per consumption good g (equation (1)) and data sources.

The first term on the right-hand side of equation (1) is the expenditure amount on good *g* in the consumption bundle for household *h*, or exp_h^g. The consumer survey provides detailed information on consumption patterns across US household types.

For the purpose of our analysis, we track spending across five household characteristics:

- size of household (number of persons: 1, 2, 3, 4, 5+);
- region of the country (NE, MW, S, W);
- annual income category (0 to US$30k, US$30k to US$70k, and US$70k and over);
- owner with mortgage, owner without mortgage, renter; and
- urban or rural.[5]

In this way, we can capture the variation across household characteristics of interest. While we consider five household characteristics in this exercise, the methodology could be expanded to consider other household characteristics of interest.

The household expenditure data were obtained from the CE Survey, conducted by the United States Census Bureau for the Bureau of Labor Statistics (2015). We used the diary survey that tracks the buying habits of US households on a relatively detailed level. The diary survey is self-administered and each consumer unit (household) keeps a diary for two one-week periods. Households record their spending on goods and services, which are categorised by the Universal Classification Code (UCC).[6] Our calculations are based on the diary survey for 2015 with a sample size of 12,175 consumer units (households).

Whenever a product category covered by the EGA corresponds directly with a category contained in the CE Survey (U.S. Bureau of Labor Statistics 2015), then the household expenditures are simply taken directly from the survey data. Often, however, the EGA category is more narrowly defined than CE categories. In such instances there is no one-to-one match between the EGA product and broader UCC survey category. Where this is the case, we need to match EGA with UCC categories gathered from the CE Survey (U.S. Bureau of Labor Statistics 2015). To that end, we first estimate the nationwide average household spending on EGA product category *g* using the best publicly available data sources. In a second step, we determine the UCC category *i* that best matches with EGA category *g*. Lastly, as different household groups spend income differently, we estimate the share of EGA product category *g* within the larger UCC category *i* for different types of households. Here, we make use of the relative differences in the expenditure patterns of household *j* in the corresponding UCC category *i* to obtain household *j*-specific expenditure estimates on good *g*. Specifically:

5 Rural is defined as living outside a metropolitan statistical area (MSA) and within an area with a population of less than 2,500 persons. An MSA is generally defined as a large population nucleus, together with adjacent communities that have a high degree of economic and social integration with that nucleus, see United States Census Bureau (n.d.). As of 1 July 2015, 85.6 percent of the US population lived in an MSA. Appendix C presents a map of the United States by urban and rural areas as defined by the US Census.

6 Expenditures in the survey are published in terms of six-digit UCC codes, for instance: 190903 Food and non-alcoholic beverages at restaurants, cafes, fast food places on trips; 190904 Food and beverages purchased and prepared by households on trips; 200900 Alcoholic beverages at restaurants, cafes, bars on trips; 210110 Rent of dwelling; 210210 Lodging away from home on trips; 210310 Housing for someone at school; 210901 Ground rent—owned home; etc.

(2) $$exp_{g,j} = exp_{EGA_g} \cdot \frac{exp_{ji}}{\overline{exp_i}} ,$$

Where:

exp_{EGA_g} denotes the national household spending for product *g* (LED light bulbs, bicycles, SCWFs, etc.), and

$\frac{exp_{ji}}{\overline{exp_i}}$ denotes the ratio of (household *j* spending on survey category *i*) to (average household spending on survey category i), and where *j* = family size, geographical region; income; tenure; urban or rural.

To illustrate our approach, consider for example the category of LED light bulbs. Based on publicly available data, we estimate that, exp_{EGA_g}, the average US household spends US$69.51 per year on LED light bulbs (see Appendix A for detailed estimates). The corresponding survey category that includes light bulbs as a subset is "misc. household products," and the average household spending on this broader category ($\overline{exp_i}$ in the above equation) is US$167.96 according to the CE Survey (U.S. Bureau of Labor Statistics 2015). However, spending on category "misc. household products" is different across household types *j* (exp_{ji}), as reported directly in the CE Survey. For example, households with one person spend US$98.28 on "misc. household products," and those with four persons spend US$206.96. Equation (2) for household expenditures on the subgroup LED light bulbs (*g*) for one-person and four-person households, respectively, can be expressed as:

$$exp_{LED,\ HH\ with\ 1} = 69.51 \cdot \frac{98.28}{167.96} = US\$40.67; \text{ and}$$

$$exp_{LED,\ HH\ with\ 4} = 69.51 \cdot \frac{206.96}{167.96} = US\$85.65$$

That is, while the national average household spends US$69.51 on LED light bulbs, the household spending variation in the broader category "misc. household products" informs us of household spending on LED light bulbs, and we find a one-person household spends US$40.67 on LED light bulbs and a four-person household spends US$85.65.[7]

The second term on the right-hand side of equation (1) denotes the change in price of good g, which we specify as the change in the import tariff.[8]

The tariff rates were obtained from the World Trade Organization's Tariff Analysis Online Database. We used the 6-digit Harmonized Tariff Schedule (HTS) level and the most-favoured-nation (MFN) rate. Many of the negotiating countries have existing regional trade agreements that involve a lower preferential rate for certain trading partners. To that extent, we may be overestimating the tariff cut. However the incidence of not claiming the preference is sufficiently high in many countries as well, which would suggest the applied rate would be more appropriate. We do not adjust for preferential rates.

3.2 Energy Cost Savings

In order to calculate the energy cost savings, we start with a price elasticity of demand. We assume the demand for environmental goods is generally elastic. Demand for these goods has been consistently increasing, year over year, for the past several years and is expected to increase in the years to come as consumers increasingly become more environmentally aware (McKinsey and Company 2012). (We assume an elasticity of 1.5.) Using the elasticity we calculate the implied

7 Our calculations are based on the constant proportionality assumption, i.e. that the expenditure share of environmental good g in the broader survey category *i* is constant across household *j*.

8 The relationship between tariffs and product prices is fairly straightforward: as tariffs decrease, prices in the importing country decrease. How this relationship works (i.e. the extent of price transmission and timing), however, is less clear. Due to lack of data to estimate the relevant pass-through elasticities, we assume perfect price transmission, or unitary elasticities. To the extent pass through is less than unitary, then in practice we would be overestimating the income effect. Our goal, however, is to understand the distributional and household-level effects and as such the relative household effects will be correctly identified.

percentage change in quantity demanded, and then calculate the volume effect in terms of units sold. The energy cost savings is then the volume effect multiplied by the energy cost savings per unit. The step-by-step calculations of the energy cost savings are described in Figure 1.

Figure 1. Calculating energy cost savings

Price elasticity of demand	Percentage change in quantity demanded (in %)	Volume effect (in units sold)	Energy cost savings (in US$)
• ε_g • Value: 1.5	• $\Delta Q_g = Q_g * \varepsilon_g$	• $VE = \Delta Q_g * Q_g$	• VE * energy cost savings per unit (in US$)

3.3 Matching Data Sources

Our empirical analysis is based on two data sources that need to be matched in order to determine how the EGA will affect US households. We match the trade data, which are in terms of 6-digit HTS codes, to the corresponding survey data, which are in terms of UCC categories as shown in Figure 2.

For instance, consider the product category "bicycles and parts and accessories." The corresponding HTS codes are "bicycles and other cycles, not motorized" and "parts and accessories (of bicycles): other: saddles," 8712.00 and 8714.95, respectively. The corresponding UCC is "bicycles" UCC 600.310. In a last step, the EGA categories have to be matched with the UCC code.

Figure 2. Product description, MFN rate, HS code, and CE Survey code

General product description	MFN rate (%)	"HS6 (2012)"	Corresponding category in Consumer Expenditure Survey
Solar control window film	6,5	3919.90	240320, 230000, 230110
	4,2	3920.62	
	4,2	3920.91	
Gas detectors and alarms	1,3	8531.80	231000, 230900, 230000, 230110
Motion sensor switches	2,7	8536.50	231000, 230900, 230000, 230110
LED lamps, fittings; compact fluorescent bulbs	4,7	9405.40	331510
	2,5	8543.70	
	2,4	8539.31	
Bicycles and parts and accessories	11,0	8712.00	600310
	8,0	8714.95	
Thermostats with automatic regulating or controlling instruments	1,7	9032.10	231000, 230900, 230000, 230110
Gas, liquid, electricity supply and production meters capable of electronic transmission of consumption data	2,6	9028.10	231000, 230900, 230000, 230110
	2,9	9028.20	
	2,8	9028.30	

Source: Tariff data were obtained from Tariff Analysis Online Database, WTO. EGA country list includes: Australia, Canada, China, Costa Rica, the European Union, Hong Kong, Japan, Korea, New Zealand, Norway, Singapore, Switzerland and Chinese Taipei. Applied rate calculated as calculated duties/customs value. The Consumer Expenditure Survey reports household expenditures as categorised by Universal Classification Code (UCC) titles and the corresponding UCC titles for each product category are reported here.

4. RESULTS

As explained above, we consider two aspects of the expected cost savings for US households from the EGA. One, the EGA will result in a decrease in prices for environmental goods (price effect). Another aspect is the energy cost savings effect. That is, the decrease in prices of environmental goods will lead to an increase in quantity demanded (quantity effect) and facilitate increased energy savings for US households, such as reduced utility bills, as well as beneficial environmental effects.

Figure 3. Annual US household savings

Product	Annual household savings, by product (US$ million)
Bicycles	431
LED bulbs	320
Alarms	23
Electricity meters	29
Motion sensors	14
Solar control window film	10
Water meters	7
Automatic thermostats	5
Gas detectors	4
Gas meters	2
Total	*845*

Source: Authors' calculations.

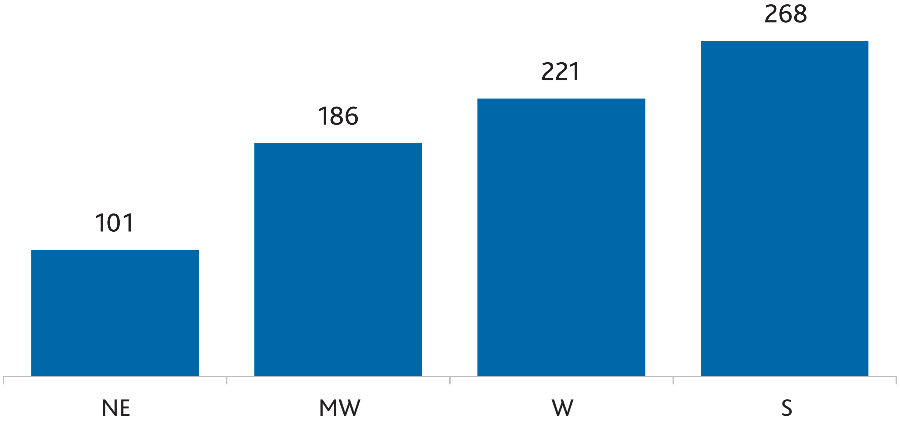
4.1 Household Price Effects

This section reports the estimated household price effects, in terms of overall by product, and then in terms of the household characteristics.

Applying equation (1) to the data and the EGA tariff cuts, we find that estimated annual household savings from the tariff cuts are approximately US$845 million (Figure 3). Most of the savings are related to bicycles and energy-efficient light bulbs (e.g. LED bulbs)—US$431 million and US$320 million, respectively. These estimates reflect the relatively large tariff cut on bicycles and the common presence of light bulbs in most household expenditure bundles.

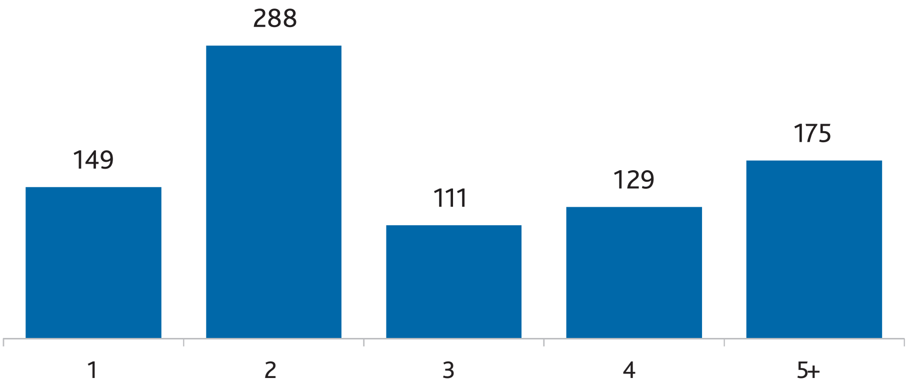
In terms of geographic regions, the South and West are estimated to accrue larger benefits, which reflects the larger number of households in the South and the bicycle-friendly culture in areas in the West (Figure 4).

Figure 4. Total annual household savings, by geographical region (million US$)



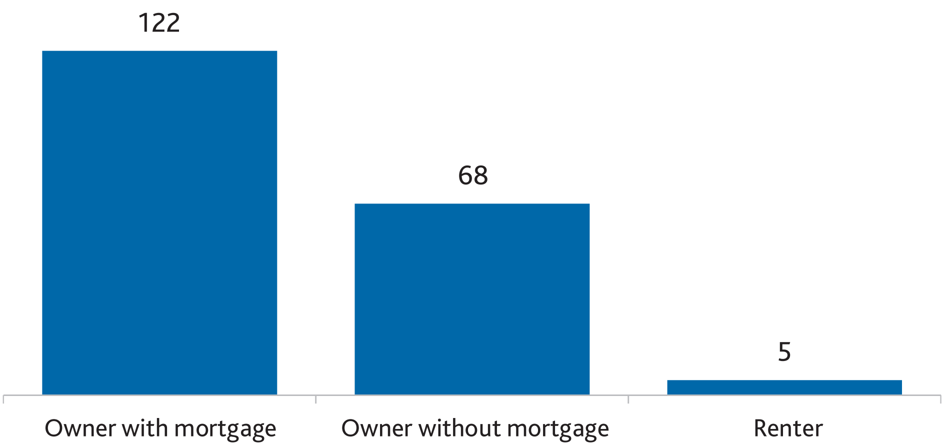
In terms of household size, households with two persons are estimated to benefit the most, which reflects the large number of two-person households (Figure 5). The group with the next largest benefits is households with five or more persons, which is driven by the relatively high level of home-related expenditures incurred by larger family households.

Figure 5. Total household savings, by household size (number of persons in household) (million US$)



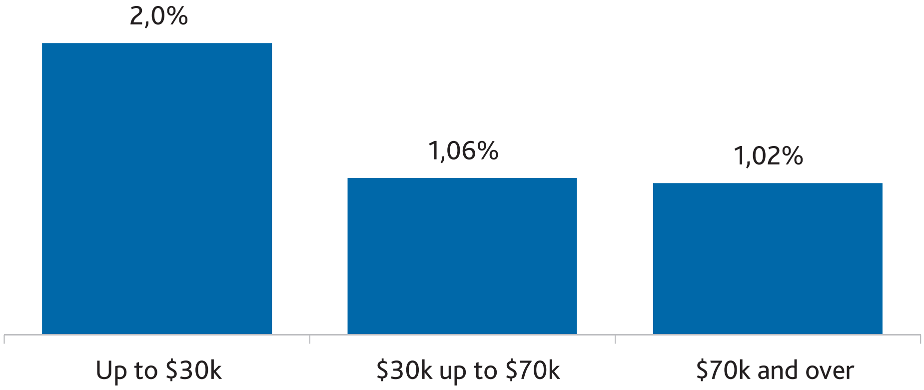
In terms of owner or renter status, the estimated savings are greater for homeowners—especially owners with a mortgage—than for renters (Figure 6). This reflects the larger number of owners than renters, and also that the average owner with a mortgage has larger expenditures on household products and housing construction products.

Figure 6. Total household savings, bytenure - homeowner or renter (million US$)



Finally, and perhaps most interestingly in terms of distributional effects, household savings vary in terms of income. We consider three income groups: up to US$30k, US$30k up to US$70k, and US$70k and over. Not surprisingly, total annual household savings increases with income (US$86 million, US$213 million, and US$404 million, respectively). Looking at the savings in terms of income, however, the savings have a greater impact for lower-income households (Figure 7). The savings as a share of income by income group (expressed as a percentage multiplied by 100) are nearly double for low-income households than for middle- and upper-income households.

Figure 7. Average household savings of the EGA,as share of household income, by income group (% x 100)



4.2 Energy and Cost Savings

We focus on the two more broadly defined products: LED and CFL light bulbs and SCWFs.

4.2.1 LED and CFC bulbs

Per the approach described above, if prices decline by 3.6 percent (the tariff reduction in tariffs LED and CFC bulbs), the quantity demanded increases by 5.4 percent or 6.9 million LED bulbs (127.734 million consumer units x 5.4 percent). The United States Department of Energy suggests that the annual cost saving per LED bulb is US$3.80. Consequently, multiplying the increase in sales of LED light bulbs by annual cost savings of US$3.80 allows us to calculate the total annual household savings in electricity bills, which is equal to US$26.22 million (6.9 million x US$3.80), and 238 million kilowatt hours saved each year (US$26.22 million in household savings/US$0.11 per kilowatt hour).[9] Given that each ton of coal can generate 1,927 kilowatt hours of usable electricity (Kenward 2011), then it follows that the energy savings are equivalent to roughly 124,000 tons of coal.

In sum, our results suggest that a 3.6 percent tariff reduction in LED and CFC bulbs will save US households US$129.6 million on electricity bills each year. The associated increase in the usage of energy-efficient bulbs is estimated to save 238 million kilowatt hours in the United States (or 124,000 tons of coal) each year. To put this figure in context, the U.S. Energy Information Administration reported that in 2015, coal consumption in the District of Columbia and State of New York was 2,000 tons and 1.76 million tons, respectively (U.S. Energy Information Administration 2016).

4.2.2 Solar control window films

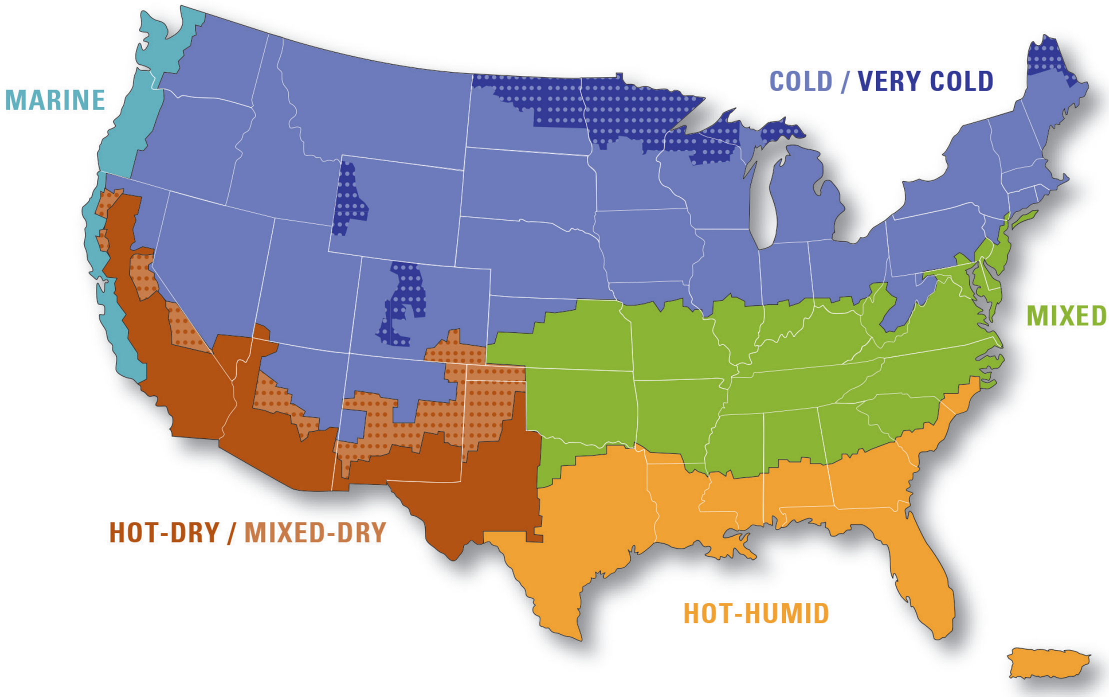
Similarly, demand for SCWFs has been growing and is expected to continue to grow as US households increasingly become more environmentally aware and seek to reduce energy consumption and utility bills. We assume price elasticity of demand is 1.5, hence a tariff

9 Annual energy cost is US$4.80 for 60W traditional incandescent and US$1.00 for 12W LED (equivalent to 60W traditional in light output); US$4.80 less US$1.00 = US$3.80 in annual energy cost savings; and these figures are based on two hours/day of usage, an electricity rate of 11 cents per kilowatt-hour. See U.S. Department of Energy (n.d.).

reduction of 5 percent would be expected to yield a 7.5 percent increase in quantity demand. Given the US$200 million market for SCWFs as noted above, then the estimated increase in quantity demand is US$15 million. With the average SCWF project between US$500 and US$1000 (i.e. one to two bedrooms and a large wall of windows), then 15,000 to 30,000 households would benefit from increased energy savings in the order of 4.8 percent to 9.9 percent (DeBusk 2013). To the extent that usage of SCWFs is correlated with heat, then these savings would be concentrated among households in hot climate zones, such as the South and West (Figure 2).

In sum, our results suggest that a 5 percent tariff reduction in SCWFs will help 15,000 to 30,000 US households save 4.8 percent to 9.9 percent on their electricity bills each year.

Figure 8. Climate zones across the United States



Source: U.S. Department of Energy 2015 (p2)

5. CONCLUSION

In this paper, we consider potential effects of the plurilateral EGA for US households. The agreement is set to eliminate tariffs for a range of environmental goods, and we focus on a group of products that households purchase directly. We estimate the "price effect" from lower tariffs, as declining prices bring lower acquisition costs on quantities already purchased by US households. We also estimate the "volume effects" and corresponding energy cost savings. These volume effects are reaped by US households, since lower prices of environmental goods may lead to an increase in quantity demanded, and consumers substitute towards the more energy-efficient goods, thus saving on running costs.

We utilise the CE Survey (U.S. Bureau of Labor Statistics 2015) and exploit the heterogeneity in consumer spending patterns across different household types. There are numerous household characteristics in the survey; for the purposes of this exercise we focus on geographic region, urban or rural location, size of household, income, and homeowner or renter status.

Regarding price effects, we estimate that if ratified, total household savings from EGA tariff cuts would be roughly US$845 million per year across the United States. Yet, we also find that the effects would be distributed heterogeneously among different socio-demographic and geographic groups. Specifically, more savings will accrue for lower-income households than middle and upper-income households, as lower-income households spend a larger share of their income on products covered by the agreement. Also, homeowners, particularly those with a mortgage, (relative to renters) are expected to accrue more of the benefits, as they spend more on the products covered by the EGA.

In terms of volume effects and the subsequent energy cost savings that result, we find that greater usage of SCWFs is estimated to help 15,000 to 30,000 US households save 4.8 percent to 9.9 percent on their electricity bills each year. Also, greater dissemination of LED and CFL bulbs could save US households US$129.6 million on electricity bills each year. Greater usage of energy-efficient bulbs is estimated to save 238 million kilowatt hours in the United States (or 124,000 tons of coal) each year. To put this figure in context, the U.S. Energy Information Administration reported that in 2015, coal consumption in the District of Columbia and State of New York was 2,000 tons and 1.76 million tons, respectively.

This paper offers a short demonstration of the feasibility of household-level analysis of tariff elimination. Researchers may find household-level analysis to be a useful complement to economy-wide analysis such as computable general equilibrium modelling, particularly when trying to understand potential distributional effects of trade policy.

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APPENDIX A: EXPENDITURES AND SAVINGS ON EACH PRODUCT AND ILLUSTRATIVE EXAMPLES

This appendix describes the average household expenditure estimates on the products that are a subset of category in the Consumer Expenditure (CE) Survey (U.S. Bureau of Labor Statistics 2015). We also provide examples to help illustrate how US households may realise the savings from the Environmental Goods Agreement (EGA).

1. Solar Control Window Films (SCWF)

Average household expenditures

The global market value for SCWFs was estimated to be roughly US$505.1 million in 2015 (Grand View Research 2016), and the value of the US market was approximately US$200 million (Flores 2014). The three segments of this market include construction, automotive, and others. Given that the total number of consumer units (from CE Survey) is 127,734,000, then US$200 million/127.734 million units = US$1.57 per household consumer unit.

The amount that a household may spend on SCWF varies by size of house, the number of windows, interest in filming just one wall (e.g. southern-facing) or more, and so on. Recent consumer examples indicate that a home project might include a huge wall of windows that costs US$2k, while a standard bedroom might be US$400 to US$600 (Henderson 2016). Window film can range from US$2.25 to US$4.00 per square foot, up to over US$10 per square foot for higher end films (TintCenter 2011).

Illustrative examples

The elimination of a 5 percent tariff on SCWFs will yield cost savings for a range of household projects:

- Auto window tinting: US$100 to US$400 per car, depending on the quality of the film and the size of the automobile (Moor 2015). Savings: US$5 to US$20;
- A bedroom: US$400 to US$600. Savings: US$20 to US$30; and
- A large wall of windows (as pictured above from Henderson 2016): US$1,000 to US$2,000. Savings: US$50 to US$100.

2. LED Lamp Fittings; Compact Fluorescent Bulbs

Average household expenditures

The average US home has 45 light bulbs and keeps each bulb on for 2 hours a day,[10] which is equivalent to 90 hours per day, or 32,850 hours per household per year. Assuming one traditional incandescent bulb lasts 1,000 hours (U.S. Department of Energy n.d.), then the average US home is estimated to buy 32.8 bulbs per year (32,850/1000=32.8).

Assuming that one of every three light bulb purchases these days is LED or CFL, then 32.8/3 = 10.93. That is, the average household with 45 light bulbs purchases 10.93 LED light bulbs per year. With the average cost of US$6.36/bulb (using 10 most popular LED bulbs on walmart.com), the average household spends US$69.51 (US$6.36 x 10.93) on LED light bulbs per year.

Illustrative examples

The tariff reduction is equivalent to a 3.6 percent price discount on energy-efficient bulbs such as LED or compact fluorescent. For instance, over time, as the average person replaces all the bulbs in their home or apartment, at 45 bulbs per residence, the savings will add up to over US$10. Another example is modern light fixtures, many of which require multiple light bulbs. The photograph to the right is from a magazine on apartment living (Fitzjarrald 2015). The savings on fitting this fixture with 12 bulbs would be US$3.80.

10 Sources indicate that the average home has 40 to 50 light bulbs. See Energy Star (2006, n.d.). The average household keeps a light on approximately two hours a day. See U.S. Department of Energy (2012)

3. Bicycles

Average household expenditures

According to the CE Survey, the average US household spends US$30.68 on bicycles each year.[11] This figure will vary by income, residential location, and a number of other factors.

Illustrative examples

There is a wide range of bicycle price points. The tariff cut translates into an 11 percent price discount. Here are three examples,

- Lower price point, US$80, Roadmaster Granite Peak Boys' Mountain Bike (Walmart). Savings: US$8.80;
- Middle price point, US$500, Diamondback Podium 24" bike, junior, female (REI). Savings: US$55; and
- Higher price points, US$2500 to US$7000 (various speciality cycling shops). Savings: US$275 to US$770.

For instance, a family of four purchasing two adult bikes at US$600 each and two junior bikes at US$200 each would realise US$176 cost savings.

4. Energy-Efficient Household Supplies and Equipment

Average household expenditures

There are at least seven products in the EGA that a household would purchase directly:

- Automatic thermostats
- Smart water meters
- Smart gas meters
- Smart electricity meters
- Motion sensors
- Gas detectors
- Alarms.

We estimate the average household expenditure on each product, utilising publicly available data and information. Generally, we take the total residential market value of expenditures and divide by the number of consumer units (households) as given in the 2015 CE Survey. A product-by-product description follows. We use the mid-range price of the best-selling product on Amazon.

For automatic thermostats, we assume two are installed in each newly built home; at US$130 each, total expenditures on automatic thermostats would be estimated at US$300 million. For water meters, we assume one per unit is installed in each newly built home. The average price of a smart water meter is estimated at US$200 per unit, which results in US$230.8 million in total annual expenditures. For gas meters, we assume one is installed in half of all new homes, at US$100 each, which results in US$57.7 million in annual expenditures. The U.S. Department of Energy reported that 5.2 million smart electricity meters were installed in 2014, and assuming a US$200 unit price, the total expenditures on household installations is approximately US$1.04 billion. For motion sensors, we assume 40 percent of households use motion sensors and 20 percent of these households either purchase new or upgrade each year (which implicitly assumes a five-year lifespan). With an average cost of US$50 per unit then the total expenditures are estimated to be US$510.9 million. For gas detectors, we assume 50 percent of new homes use natural gas and each new home has two gas detectors; for existing homes we assume a 10 percent replacement rate, and with average unit price of US$40, then total expenditures are roughly US$332.3 million. Finally, for alarms, we assume all newly built units have an alarm, and 20 percent of existing homes have an alarm with a 25 percent replacement or upgrade rate. Using an average unit price of US$260, then total expenditures are approximately US$1.799 million.

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11 Bicycles is UCC 600 310 in the CE Survey.

Illustrative example

Consider a person who moves into a new home or apartment and purchases these energy-efficient residential supplies and equipment. Combined, they will spend US$980 on all of these products, and with the tariff reductions ranging from 1.3 percent to 2.9 percent, the price reductions considered here will result in cost savings of US$12 to US$28.

APPENDIX B: HOUSEHOLD TRADE MODEL

Here we provide the entire Nicita, Olarreaga, and Porto (2014) model of household-level welfare effects of trade policy, in which changes in a household's welfare depends on the changes in local prices, household-specific labour income, household-specific capital income, and household-specific consumption. The model can be expressed as:

$$d\tilde{y}_h^g = -s_h^g dlnp_g + \theta_h^w \varepsilon_{wp_g} dlnp_g + \theta_h^g dlnp_g + \theta_{h,g,s,c}^T \varepsilon_{wp_g} dlnT$$

$d\tilde{y}_h^g$: the change in the income of household *h*. Household *h* can be subscripted itself such as h_{gsc}, which denotes the primary income earner in household *h* that works in industry *g* with social-economic background *s* living in geographic region *c*

s_h^g : the share of good *g* in consumption bundle of household *h*

$dlnp_g$: trade policy-induced change in the price of good *g*

θ_h^w : the share of household income derived from labour earnings

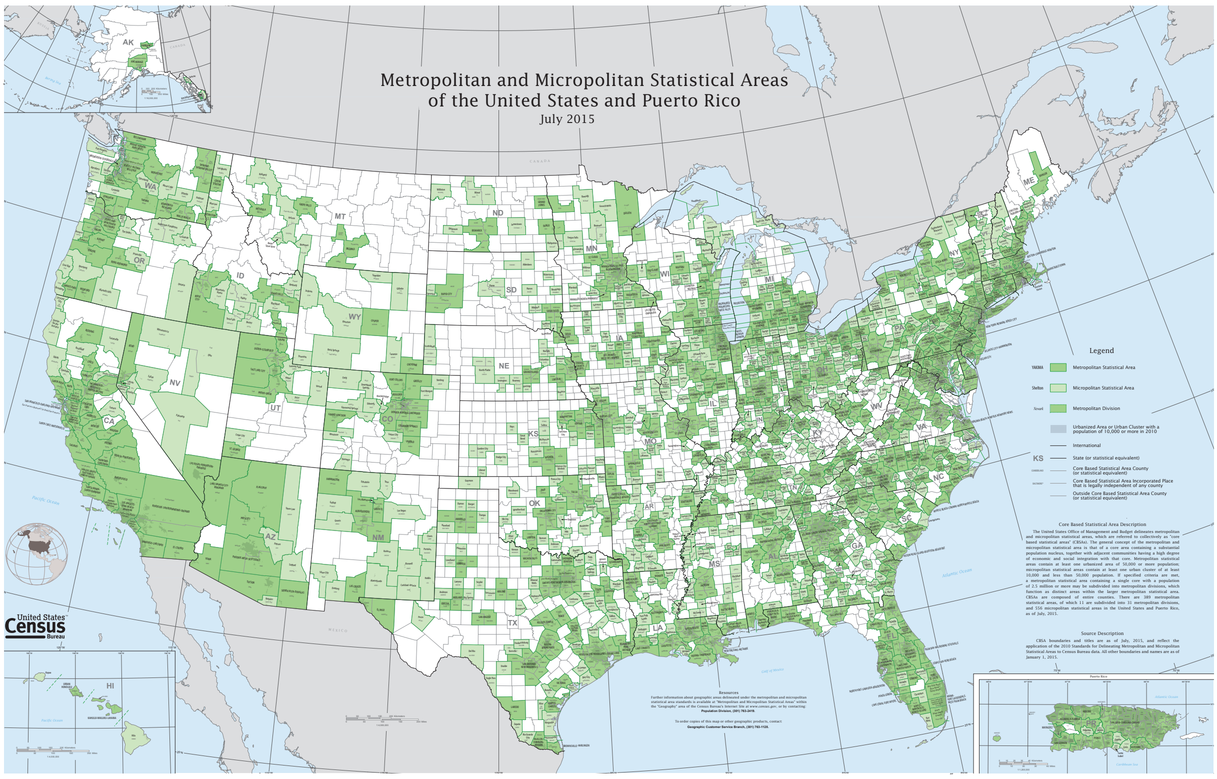
ε_{wp_g} : the elasticity of wages with respect to changes in p_g

θ_h^g : the share of household income derived from distributed profits of industry producing good *g*

θ_h^T : the share of tariff revenue accrued by the household

$dlnT$: the change in tariff revenue.

APPENDIX C: MAP OF METRO AND MICROPOLITAN STATISTICAL AREAS, JULY 2015, US CENSUS



Source: U.S. Census Bureau. n.d. "Metropolitan and Micropolitan Statistical Area Wall Maps." *http://www2.census.gov/geo/maps/metroarea/us_wall/Jul2015/cbsa_us_0715.pdf*

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