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INTERNATIONAL TRADE REGULATIONS ON BPA: GLOBAL HEALTH AND ECONOMIC IMPLICATIONS

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ABSTRACT

Several international trade agreements being negotiated today are mostly aimed at enhancing trade and economy, with less or no concern about other important aspects, including environment. However, there have been some trade regulations as well as rules within some of these agreements that aim at enforcing stringent requirements and constraints on free trade of certain commodities that harm the environment and increase risk factors of diseases. Bisphenol A (BPA) is one such commodity and is the focus of this paper. Despite its heavy use across the world, BPA has severe health and ecological effects, leading the developed countries to impose regulations on them. This paper reviews the adverse health and ecological effects of BPA as well as the regulations on them. It further goes on to perform an economic model simulation using a widely used global model named GTAP, to understand the global economic effects of banning the trade of BPA. We also estimate the costs arising from the adverse health effects of BPA using WHO-DALY dataset and the literature. We arrive at a range of costs associated with health and conclude that regulating BPA is at best, a very inexpensive policy to promote health and economies of the world, and at worst, slightly more expensive than the health costs associated with BPA.

Contribution/ Originality: This study's primary and unique contribution is the analysis of the impact of trade regulations on BPA, in an interdisciplinary way, covering aspects of chemistry and economic modeling.

1. INTRODUCTION

International trade involves exports and imports of commodities across the world. In the recent decades, several countries have been negotiating and implementing agreements that enhance these economic relationships among them. Several of these Regional Trade Agreements (RTAs) are mostly aimed at enhancing trade and economy, with less or no concern about other important aspects, including health. However, there have been some trade regulations as well as rules within some of these RTAs that aim at enforcing stringent requirements and constraints on free trade of certain commodities that increase risk factors of diseases. Bisphenol A (BPA) is one such commodity and is the focus of this paper. Bisphenols are a group of chemical compounds with two hydroxyphenyl functionalities (Liao and Kannan, 2013). Among them, Bisphenol A (BPA) has been the most widely studied and used (Kuang *et al.*, 2013; Schöpel *et al.*, 2013; Zhang *et al.*, 2013). BPA was first synthesized by A.P. Dianin in 1891, and was in commercial use since the 1960s (U.S. Food and Drug Administration (FDA), 2013). BPA can make plastics colorless transparent, durable, light and handy, and outstanding anti-impact characteristics. (European Information Center on Bisphenol A, n.d). Especially, BPA can prevent the erosion of acidic fruit and vegetables from the internal metal containers. Therefore, the use of BPA focus on the manufacture of polycarbonate plastics, e.g., water and infant bottles, compact discs, impact-resistant safety equipment and medical devices and epoxy resins used in dental fillings, bottle tops, water supply pipes and food can linings (National Institute of Environmental Health Sciences (NIH), 2013). In addition, BPA is also used in paper for some receipts. Nowadays, at least 3.6 million tonnes of BPA will be used by industry each year (U.S. News & World Report, 2009). Recently, a new research report titled "Bisphenol A: A Global Strategic Business Report" reported by Global Industry Analysts, Inc. (GIA), provided a comprehensive coverage of factors shaping the global BPA, and GIA forecasted the global BPA market will reach 8.4 million tonnes by 2018 (Global Industry Analysts, n.d). Despite its heavy use across the world, BPA has severe health and ecological effects. Therefore, several developed countries have started imposing stringent trade regulations on BPA. In this paper, we analyze the global economic and health impact of such proposed and implemented regulations, using the widely used GTAP (Global Trade Analysis Project) model. The broad finding is that such regulations have very little negative impact in terms of economic variables such as GDP (Gross Domestic Product) and employment, while the potential health benefits of avoiding the incidences of several diseases caused due to BPA are much higher. This paper is organized as follows: sections 2 and 3 review the health and ecological implications of BPA, respectively, while section 4 sets the stage by discussing the regulations associated with BPA. Section 5 explains the model, while section 7 discusses the results and section 8 concludes.

2. HEALTH EFFECTS OF BPA

BPA concentrations in surface water vary considerably depending on the location and sampling period, and are mostly below 0.08-12.5 μg L^{-1} (Flint *et al.*, 2012; İpek *et al.*, 2014). BPA exposure was estimated to be associated with 12,404 cases of childhood obesity and 33,863 cases of newly incident coronary heart disease, with estimated social costs of $2.98 billion in 2008. Removing BPA from food uses might prevent 6,236 cases of childhood obesity and 22,350 cases of newly incident coronary heart disease per year, with potential annual economic benefits of $1.74 billion (sensitivity analysis: $889 million–$13.8 billion per year). These potentially large health and economic benefits could outweigh the costs of using a safer substitute for BPA, as we show in this paper (Trasande, 2014).

Because of widespread human exposure to BPA, BPA has drawn considerable attention by the general public and many organizations (Schecter *et al.*, 2010; Fischer *et al.*, 2013; Migeot *et al.*, 2013). The National institute of Environmental Health Sciences (NIEHS) pledged $30 million, and many researchers came up with addition funding to examine the health effects of BPA. (Sandy, 2014) Migration of BPA from polycarbonate drinking and baby bottles into water and foods has been reported (Cao and Corriveau, 2008; Le *et al.*, 2008; Cooper *et al.*, 2011; Liao *et al.*, 2012). Until now, the biggest problem troubling the humans is that BPA is an "endocrine disruptor," which means BPA can interfere with human hormonal systems. Especially, it mimics estrogen. Moreover, BPA can arouse many additional health problems, including weight gain, early-onset of puberty, infertility, behavioral changes, cardiovascular effects and diabetes (Morgan *et al.*, 2011; Johnson *et al.*, 2012; Liao *et al.*, 2012; Wang *et al.*, 2012). One recent study even found that the early exposure to BPA can lead to prostate cancer (Hileman, 2007).

3. ECOLOGY EFFECTS OF BPA

Global production of BPA was about 4 million tons in 2006 in next couple of years which is by 2008 it has increased by a million tons (Chemical Weekly, n.d). The wide use of BPA by plastic and other industries have led BPA to be present everywhere in the environment, mostly effecting the water bodies and landfills (Yamada *et al.*, 1999; Yamamoto *et al.*, 2001; Fauser *et al.*, 2003). BPA is usually detected in waste water discharged from municipal and industrial areas. Efforts have been made by Japan, to see the percent of BPA in untreated and treated water as a survey. This research survey has indicated that BPA was detected in 44% of raw water and 8% of purified water from 25 different water treatment plants, indicating that BPA is present everywhere (Tabata *et al*., 2004).

4. REGULATIONS GOVERNING BPA

U.S. FDA has responsibility for regulating the compound, and had stated that BPA has some potential effects on the brain, prostate glands of fetuses, infants and children. In July 2012, U.S. FDA has banned the use of BPA in children's baby bottles and drinking cups, and has expressed no concerns of it being used in other consumer products. Several states in US including the district of Columbia have enacted to the restrictions of BPA since 2009. California assembly bill 1319 (2011);_*West's Ann.Cal.Health & Safety Code § 108940-108941*, This law prohibits the manufacture, sale or distribution of BPA products with a detective level above 0.1 parts per billion, and the products that are meant for children, need to replace BPA with a less toxic material and is effective from July 1 2013. Connecticut house bill 6572 (2009), *C.G.S.A. § 21a-12b to -12c*, this law enacted in 2009 bans the manufacture, sale and distribution of reusable food or beverage containers which include Baby bottles, spill-proof cups, sports bottles and thermoses, that have BPA and was effective from October 1, 2011. Connecticut senate bill 210 (2011), *C.G.S.A. § 21a-12e*, this law has taken a step forward and banned the manufacture, sale and distribution of the thermal receipt paper or cash register receipt paper containing BPA, and would be effective from July 1 2015. Delaware senate bill 70 (2011), *6 Del.C. § 2509*, this law prohibits the sale of the bottles or cups containing BPA, especially meant for children under four years of age and is effective from July 1, 2012 and Illinois senate bill 2950 (2011), *410 ILCS 44/10*, and Minnesota senate bill 247 (2009) *M.S.A. § 325F.173-175*, has similar conditions but for the children under 3 years and the ban was applied to the manufacturers and wholesalers beginning January 1, 2013 and to retailers January 1, 2014.

Maine house bill 330 (2011), *Resolve No. 2011-25 (2011)*, has approved BPA has the priority under the state toxic chemicals in children's products law *38 MRSA §1691 et al.* Maryland house bill 33 (2010) and senate bill 213 (2010), *MD Code, Health - General, § 24-304*, this law banned the manufacture, sale or distribution of BPA containing products that are for children use and the manufacturers were asked to replace BPA with less toxic chemical. House Bill 4 (2011) and Senate Bill 151 (2011), *MD Code, Health - General, § 24-304*, this law prohibits the manufacture, sale and distribution of containers of the infants that contain 0.5 ppb of BPA and are effective from the July 1, 2014. Massachusetts 105 CMR 650.220, has adopted revisions to its hazardous substances administrative regulations that the re-useable food or beverage containers especially for children are banned and it also warned the parents not to store the milk in the plastic bottles containing the BPA. New york senate bill 3296 (2010), *NY Env Cons L § 37-0501*, this law has prohibited the sale of the pacifiers, baby bottles, sippy cups and other unfilled beverage containers for use by children under 3 years of age and is effective from the December 1, 2010. Vermont, senate bill 247 (2010), *18 V.S.A. § 1512*, this law has banned the manufacture, sale or distribution of re-usable food and beverage containers, like baby bottles, spill-proof cups, sports bottles and thermoses that contain BPA. It also bans the use of the infant's food stored in the BPA- containers and requires manufacturers to replace BPA with a less toxic chemical. Washington senate bill 6248 (2010), *West's RCWA 70.280.010 to 70.280.060*, this law prohibits manufacture, sale or distribution of empty bottles, cups or other food or beverage containers that contain BPA after July 1, 2011, metal cans are excluded. This law also bans the manufacture, sale or distribution of the empty sports bottle sof 64 ounces or less that contain BPA after July 1, 2012. The law also insist the manufactures to recall the prohibited products and reimburse the purchaser of product.

Wisconsin senate bill 271 (2010), *W.S.A. 100.335*, this law bans the manufacture or sale at wholesale or retail of the empty bottles and spill proof containers, especially for children of 3 years of age and less than that. It also requires the manufacturers to have a label as BPA-free containers. District of Columbia bill 521 (2009), *DC ST § 8-108.01*, this law bans the manufacture, sale or distribution of the BPA containers that are intended for food or beverage storage and is effective from July 1, 2011. Among other nations Canada and France banned the use of container that have BPA especially for children.

France is taking a step forward and has banned the BPA-based containers for storage of the food by 2015. Brussels-based trade body plastics Europe has said in a statement "Industry is deeply disappointed to see the French government not respecting the existing EU rules for food safety, and will be considering all options as reaction to this decision. The French decision may result in a reduction, and not an enhancement, of French consumer safety, and will create a significant distortion of the internal and international market for food contact goods in the EU." According to World Trade Organization (WTO), the French government have to notify the planned law to WTO and also the agreement on Sanitary or Phytosanitary Measures (SPS), this allows other countries to assess and respond to the intended ban within 60 days, during which the French government is not allowed to propagate the ban. French National Assembly has asked the government to submit a report evaluating the possible alternatives to replace BPA with respect to their potential toxicity before July 1, 2014, six months before whole ban of BPA containers. Plastics Europe is concerned with the statement of France to use the alternative products for small children as soon as possible, and in the same law it requests to report the toxicity of alternatives only by July 2014. This indicates that the especially vulnerable part of population is exposed to products with unknown toxicity for that period. Hence Plastics Europe is asking the companies to contact European Commission and WTO and explain the potential harmful implications of French law (Liao *et al.*, 2012). As can be seen that the concern on the safety of BPA continues to grow, basing on the similarity in the structure of different bisphenol analogues, many companies have begun to replace BPA with BPB, BPF and BPS (Pence, 2009).

5. ECONOMIC METHODOLOGY

This paper uses GTAP database version 9 (Narayanan *et al.*, 2015) and the standard GTAP model (Hertel, 1997) to analyze macroeconomic and trade impacts. This is a CGE model, which has been used for research published in journals such as Proceedings of National Academy of Sciences and Nature. This is a global Computable General Equilibrium (CGE) model. Global CGE models may serve the best if one is interested in global policy impact, particularly with an inter-sectoral linkages and constrained resources/factors perspective. GTAP model is one of the most widely used one among them and GTAP Data Base is the dataset used in tandem with this model as well as several other global CGE models. GTAP model is defined in linearized difference equations, therefore most of the variables are in percentage change. Each country/region is represented by a regional household, which has a Cobb-Douglas utility function that distributes aggregate demand into three different categories in every regional household, namely, savings, private households and government. Regional household's income comes from various taxes and primary factor payments. Savings from each region are accumulated into global savings, which is allocated to different regions as investment based on the movement of prices of capital goods as well as expected rate of return inferred from the capital stock in the beginning and end of the simulation period.

There are market clearing conditions for output (across domestic and exports), imports (by users of imports, as firms, households and government), domestic consumption (by users as assigned for imports) and endowment output (by usage in various sectors). Zero profits are assumed in the standard form of this model, implying perfect competition. This condition is employed to infer the endogenous output change in every sector.

Various types of prices in the model are linked with each other through tax/subsidy wedges, which exist across the user types, output and source of use and production. Trade links the regions, each of which has an identical model structure being outlined herein. The percentage change in bilateral imports of a commodity, for example, is derived from two terms: expansion term that arises from the overall change in aggregate imports in the importing region and substitution term that captures the shift of demand from one source to another, based on an econometrically estimated elasticity and the difference between percentage changes in bilateral import prices and those in the destination-generic aggregate prices.

Demand for commodities across the user types has a two-stage process: first, the user (firms, private household and government) decides the total demand, based on the regional household's utility function; secondly, each user decides how much of it needs to come from domestic and from imports. For firms, for example, the change in domestic consumption of a first commodity used in the production of another (second) commodity in a region is simulated by the overall change (domestic + imports) in this particular consumption (expansion effect) and the domestic-import elasticity multiplied by the differential between domestic prices of the first commodity used to produce the second commodity and aggregated (weighted average of domestic and imported prices) prices of the same.

Private households determine their expenditure based on a per-capita Constant Difference Elasticities (CDE) implicit expenditure function. Production is depicted in a multi-nest system. On the top, firms decide to produce certain quantities of output; a Leontief structure is then used to choose between the value-added composite commodity and intermediate input composite commodity; Constant Elasticity of Substitution (CES) nests are then defined among the value-added categories (usage of various factors) and different intermediate inputs.

BPA is considered to be one of the high production volume chemical (HPV) in the world. As per the final report of US-EPA in Jan 2014, global annual production of BPA in 2008, is about 5,160 kilo tons, out of which US alone contributes to 1,226 kilotons, European Union contributes to about 1,438 kilotons and remaining can be considered from the Japan, since few papers cited that, Japan contributes next to the European Union (Chemical Weekly, n.d). Cost of reagent based BPA, which is ≥99% pure is about 65.50 $ per 50 G, from SIGMA-ALDRICH website and has a CAS number 80-05-7 (Gould, 2008). Using these numbers as well as the UN COMTRADE data on international trade in BPA, we separate the BPA sector from the aggregated GTAP sector named "chemicals, rubber and plastics", in terms of international trade. We then simulate the model to remove the trade of BPA to USA and the EU, since these are the countries which have begun imposing stringent regulations. Using this model, we discuss the overall global economic impact of such a policy, in the next section.

In addition, we estimate the global economic impact of various diseases caused by BPA, using the WHO's (World Health Organisation) DALY (Disability Adjusted Life Years) dataset and World Bank's per-capita income dataset. Since the former provides the life years lost due to a given disease, multiplying this with per-capital income of a country gives an estimate of the annual value lost due to this disease. This is what we report as global health impact of the BPA herein.

6. RESULTS

Our global economic results indicate that the economic costs of artificially eliminating the imports of BPA by the EU and USA are pretty small, relatively speaking. Table 1 shows that the most significant losers in absolute terms of GDP are the EU. They lose about US$ 2.6 billion in GDP, which is in fact less than 0.01% of EU's GDP. Most of the developing countries may gain slightly in terms of GDP. The rest of this table focuses on the impact faced by the aggregated sector of chemicals, rubber and plastics, in which BPA plays a major role currently. Imports of these products fall slightly in most countries, resulting in reduction in output and a rise in prices of imports and output as well. Consequently, employment of labor as well as capital fall. However, all these changes are relatively small. Except imports for US and EU, all other changes are less than 1%.

Furthermore, a glance at table 2, which summarizes the current estimated and projected health impact of the just a couple of diseases caused by BPA, shows that these costs are substantial, totaling to about 3.3 trillion US$ in 2012 and 6.7 trillion US$ in 2030. Even if we assume that merely 0.01% of these costs is due to BPA, the effects are about 33 billion US$, which is much higher than the total global GDP loss of about 2.5 billion US$ due to the BPA regulation, derived from table 1. Even if we conservatively consider the median economic benefits of excluding BPA from food uses, estimated in the literature (Trasande, 2014) the loss in GDP shown in the paper is only slightly greater than the economic benefits of BPA regulations. The difference of about 700 million US$ is quite a small amount compared to the GDP of any country and hence the countries across the world could take this as an investment in global public health.

Table-1. Global Economic Results (all variables in % changes, except changes in GDP, which are in millions of US$)

Region	GDP	Imports	Import Prices	Output	Output Prices	Unskilled Labor	Skilled Labor	Capital
Oceania	31	-0.24	0.22	0.08	0.08	0.08	0.09	0.09
China	124	-0.21	0.13	-0.07	0.06	-0.07	-0.07	-0.07
India	5	-0.2	0.13	-0.11	0.06	-0.12	-0.09	-0.1
Rest of Asia	82	-0.22	0.15	-0.09	0.06	-0.09	-0.09	-0.09
Canada	-22	-0.09	0.19	-0.74	0	-0.75	-0.74	-0.74
USA	-54	-1.69	0.24	0.1	0.14	0.09	0.1	0.1
Brazil	64	-0.26	0.2	-0.02	0.1	-0.02	-0.01	-0.02
Rest of Latin America	1	-0.21	0.17	-0.1	0.07	-0.1	-0.09	-0.1
EU28	-2588	-4.44	0.43	-0.11	0.58	-0.08	-0.12	-0.11
Middle East & North Africa	1	-0.4	0.27	-0.08	0.05	-0.08	-0.07	-0.08
Least Developed Countries	7	-0.01	0.08	0.03	0.07	0.04	0.04	0.02
Sub-Saharan Africa	2	-0.29	0.22	0.04	0.06	0.04	0.05	0.04
Rest of the World	-151	-0.73	0.41	-1.02	0.05	-1.02	-1.01	-1.02

Source: Authors' Simulations from GTAP

Table-2. Global Economic Burden of Selected Diseases Caused by BPA (in billions of US$)

S. No	Diseases caused by BPA	References in this paper	Global Impact (2012)	Projected Global Impact (2030)
1.	Hypertension	(Bodin *et al.*, 2013; Sabanayagam *et al.*, 2013)	189.2	382
2.	Diabetes	(Leranth *et al.*, 2008; Song *et al.*, 2012; Babu *et al.*, 2013; Gong *et al.*, 2013; Kim and Park, 2013; The Peninsula College of Medicine and Dentistry, n.d)	544.09	1028.7
3.	Cancer (Risk and Resistance to therapy)	(Kimmon, n.d; Peart, n.d)	2323.2	4775.7
4.	Asthma	American Academy of Allergy and Asthma (n.d)	232.4	509.5
	Total		3288.9	6695.9

7. CONCLUSIONS

Increasingly, various global trade agreements and regulations have public health implications. BPA is an important commodity in this context, being proposed to be regulated by both US and EU. While there has been an attempt in the literature to evaluate the economic benefits of regulating BPA, there was no research done to estimate the economic costs involved in such a policy proposal. We attempt to fill this gap in this literature, and found that even at the most conservative level, the net costs of a trade regulation on BPA are less than a billion US$, which is quite small given the long-term economic benefits involved.

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