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THE IMPACT OF PESTICIDES AND DRY RESIDUAL BIOMASS ON THE ECOLOGICAL FOOTPRINTS IN OECD COUNTRIES

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Abstract: *The present study explores the impacts of pesticide usage and burned biomass on the ecological footprints in OECD countries. Based on 500 panel observations from 25 sample OECD countries during the period of 2000 to 2019, the study applies panel data regression approach. The panel data regression models are estimated by pooled OLS method in one way and fixed effects with Driscoll-Kraay standard errors method in other way. The latter method is a robust method of capturing heteroskedasticity and autocorrelation. In both estimations, the results find that pesticide usage and burned biomass have positive and significant impacts on the ecological footprints of OECD countries but in particular pesticide usage has stronger effect in Driscoll-Kraay standard errors approach and less in pooled OLS method. This means that both variables increase the PM_{2.5} concentration in OECD countries and cause climate change. Therefore, organic pest-resistant techniques and the use of residual biomass as feedstock could be the possible solutions to improve ecological footprints in OECD countries.*

Keywords: *Climate change, Ecological footprints, Pesticide usage, Bio mass burning, OECD*

JEL Classification: Q2, Q5, P42, Q580

INTRODUCTION

Pest management for crops has existed for as long as human civilization. Since the prehistoric age, people have tried to protect their food production using various crude methods. Despite the significant human effort, the development of the various plant protection methods has been noticeably slowed down as they become ineffective with the passage of time. However, during the sixteen century, chemicals were exposed to the crops for pest control (Polyrakis, 2009). However, agriculture's industrial revolution and pesticide usage positively increase crop productivity (Duttagupta et al., 2020). On the other hand, pesticide usage appears to be harmful to the environment and causes climate change (Ukhurebor et al., 2020). The massive use of pesticides in agriculture increases airborne bone particulate matter (Yera, & Vasconcellos, 2021; Year et al., 2020; Nascimento et al., 2018). Similarly, on the other hand, its use adversely affects public health (Guberman VerPloeg et al., 2019; Ghorab & Khalil, 2015).

Likewise, in recent periods, urban expansion and deforestation have caused climate change worldwide (Andrée et al., 2019). Moreover, urbanization's rapid industrialization harms the environment by increasing the carbon emission in the air (Cherniwchan, J. (2012; Patnaik, R. (2018, March). However, besides pesticides, biomass combustion also harms the environment by increasing the concentration of carbon emissions in the air (Chuvieco et al., 2021). In terms of empirical research, Zhao et al. (2017) statistically analyzed the impact of agricultural biomass burning on the environment in 10 stations in Changchun by NASA Earth Observatory's Active Fire Data. They concluded that biomass burning increases the concentration of PM_{2.5} before the harvesting period. Li et al. (2010) also confirmed a similar find in their empirical research in which Aerosol particle data were collected in urban Beijing from 12 to 30 June 2007. They conclude that one of the key factors

which cause the high concentration of haze in urban Beijing is the burning of agricultural biomass in fields around Beijing. Numerous other studies also indicate a high concentration of carbon-related particles in the air caused by agricultural biomass burning (Tian et al., 2017; Favez et al., 2009).

Recent literature indicates that environmental sustainability is a heavily debatable topic among researchers, environmental practitioners and policymakers. However, literature indicates that there are numerous factors which harm our environment during the economic growth process, such as industrialization (Pan, & Dong, 2021), urbanization (Wei et al., 2021), fossil fuels consumption (Hassan et al., 2021) and agricultural activities (Cheng et al., 2021). Developed countries transferred their industrial sector towards sustainable production and consumption pattern; however, climate change heavily impacts daily activities in developing countries (Krec et al., 2022). Non-seasonal rains, floods and droughts in developing countries are major issues raised by climate change. All these issues further impact agricultural production and consumption (Das, 2022). Besides that, unsustainable agricultural methods, massive use of pesticides, and excessive fertilizer usage harm the environment and cause concentration of air pollutant particles. Considering that environmental sustainability is not only an issue of developing countries but also it becomes a major issue for developed countries, where sustainable production and consumption patterns are usually highly regulated and adopted.

Therefore, the present study questions the dynamics of relationship among the pesticide usage, agriculture biomass burning and environmental sustainability by presenting empirical discoveries. To inject some new insights in the empirical literature, this study empirically investigates the impact of chemical use as pesticides and the burning of residual agricultural biomass on air pollution. To probe the discourse, a panel of 25 OECD countries during the period from 2000 to 2019, three variables such as fine particulate Matter (PM 2.5), Pesticide usage and agricultural dry residual biomass burned are analysed. The results of this empirical investigation offer a new fresh inside for interpreting the nexus between agricultural factors and environmental sustainability for developed countries which is further used for environmental policymaking in the agriculture sector.

The rest of paper is organised as research framework (section 2), methodology (section 3), analysis of results and discussion (section 4) and conclusion (section 5).

Research Framework

The study mainly highlights the nexus among fine particulate matter, pesticides usage and dry residual of biomass burned indices in the panel of 25 OECD countries. Undoubtedly, dry residual biomass burning and massive use of pesticides harm the environmental sustainability. Therefore, the study investigates the impact on pesticide usage and residual bio mass burning on ecological foot prints. The following figure represents a research framework of the present study.

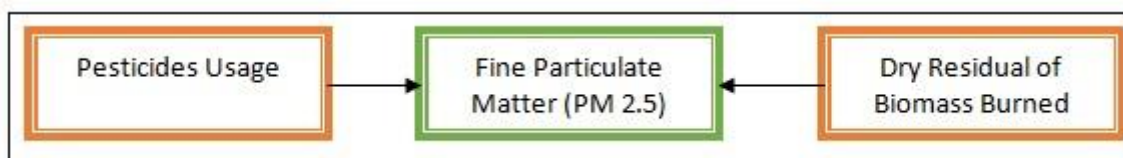


Figure 1: Research framework

Bases on the above research framework, the following multiple regression model is formulated for panel analysis. The regression equation will measure the effects of Pesticide usage (PEST) and Biomass Burned (dry residual (BMB)) on the Fine Particulate Matter (PM2.5).

$$PM2.5_{it} = \beta_0 + \beta_1 PEST_{it} + \beta_2 BMB_{it} + \varepsilon_{it}$$

Where, $i = 1, 2, 3, \dots, N$ indicates cross-sectional units and $t = 1, 2, 3, \dots, T$ indicates time period, β 's are coefficients and ε_{it} is the error term.

MATERIALS AND MEDHODS

This research concerns the 25 OECD countries to test our hypotheses, thus estimating panel data association. As panel data give us more informative data, variability, and reduced co-linearity among the explanatory variables. It also increases the degree of freedom and furthermore panel data allow us to identify and measure effects that are not detectable in pure cross-sections or time-series data. Furthermore, panel data also control individual heterogeneity (Baltagi, 2015).

Pooled OLS

Initially we assume the coefficient PM2.5 remains unchanged across all the investigated years and samples. Considering the assumption of POLS the estimates are not biased and consistent even if the heterogeneity exists in the data. Furthermore each used sample countries holds its own attributes based on location; social, political and economic factors. The refore in this situation the error term correlates with the model regressors (Panait et al., (2022).

Fixed Effect Driscoll-Karay

By considering the possibility of heterogeneity, we estimate the results by applying the fixed effect model. It incorporates the sampled country's specific policies and practices of the ecological factors and shows the effects in the intercept coefficient. " α_{1j} ". The intercept of one country differs from the other country but is time-invariant. The fixed effect captures the countries' specific effects by takings the different economic, geological and social characteristics. Ramoutar, (2017) also affirms in his empirical analysis that, the advantage of fixed effects with Driscoll and Kraay standard errors is that the problems of heteroscedasticity, autocorrelation, and cross-sectional dependence are all corrected.

RESULTS AND DISCUSSION

Based on our research hypothesis, the endogenous variables is used as PM2.5 which refer to the size of the pollutant, in micrometers in the air whereas; the other two exogenous variables are total pesticide usage (per area of cropland-Kg /ha) 'PEST' and dry residual of agriculture biomass burned in tonnes. The source of data is mentioned in Table 1.

Table 1 Source of Data and variables

Variable	Definition	Symbol	Source
Fine Particulate Matter (PM 2.5)	PM 2.5 refers to the size of the pollutant, in micrometers.	PM2.5	IEA-International Energy Agency
Pesticide usage	Total pesticide used(per area of cropland-Kg /ha)	Pest	FAO- Food and Agriculture Organization
Biomass Burned (dry residual)	All crops biomass burned (residual - tonnes)	BMB	FAO

The relative statistic of the all used variable are indicated in table 2 where as correlation analysis are mentioned in table 3. The sample average of PM2.5 is 13.78 micrometers with highest 27.18 micrometers and lowest 5.85 micrometers. The standard deviation of 4.634 reveals a minimal dispersion from the sample mean. Similarly, the sample average of PEST is 3.665 Kg /ha with highest and (13.84 Kg /ha) and lowest (0.245 Kg /ha). For PEST, the standard deviation of 2.658 reveals a minimal dispersion from the sample mean. Furthermore, the sample average of BMB is 610076.1 tonnes with highest 3982668 tonnes and lowest 4406 tonnes. Similarly for biomass burn the standard deviation of 871302.1 reveals a minimal dispersion from the sample mean. Furthermore, below figure 1,2 and 3 indicate yearly mean values of pesticides usage, biomass burn and PM2.5.

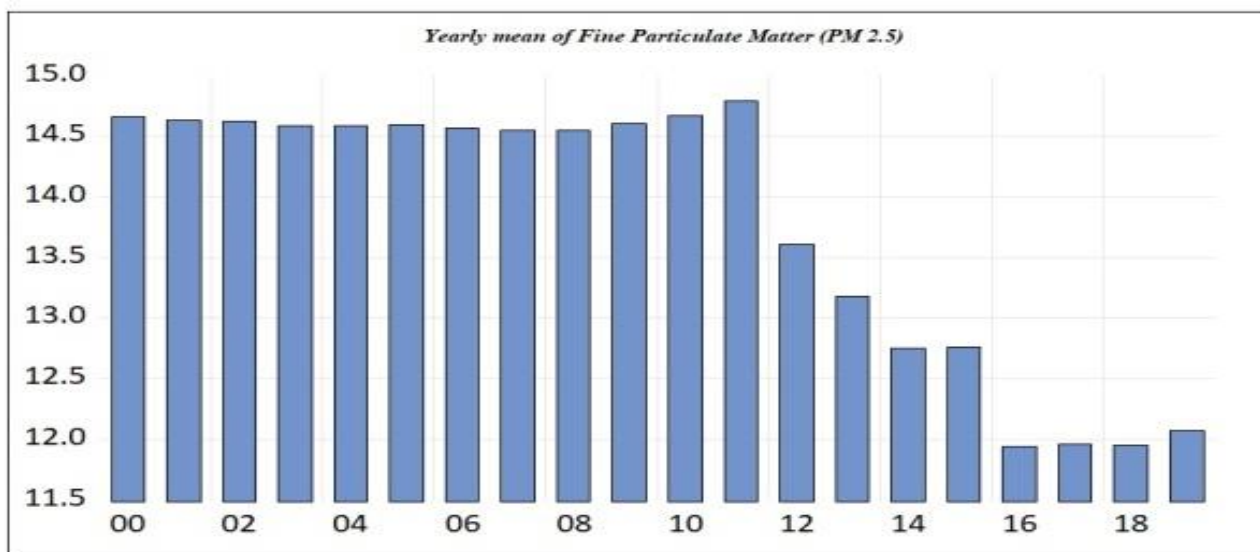


Figure 1- PM2.5 yearly mean

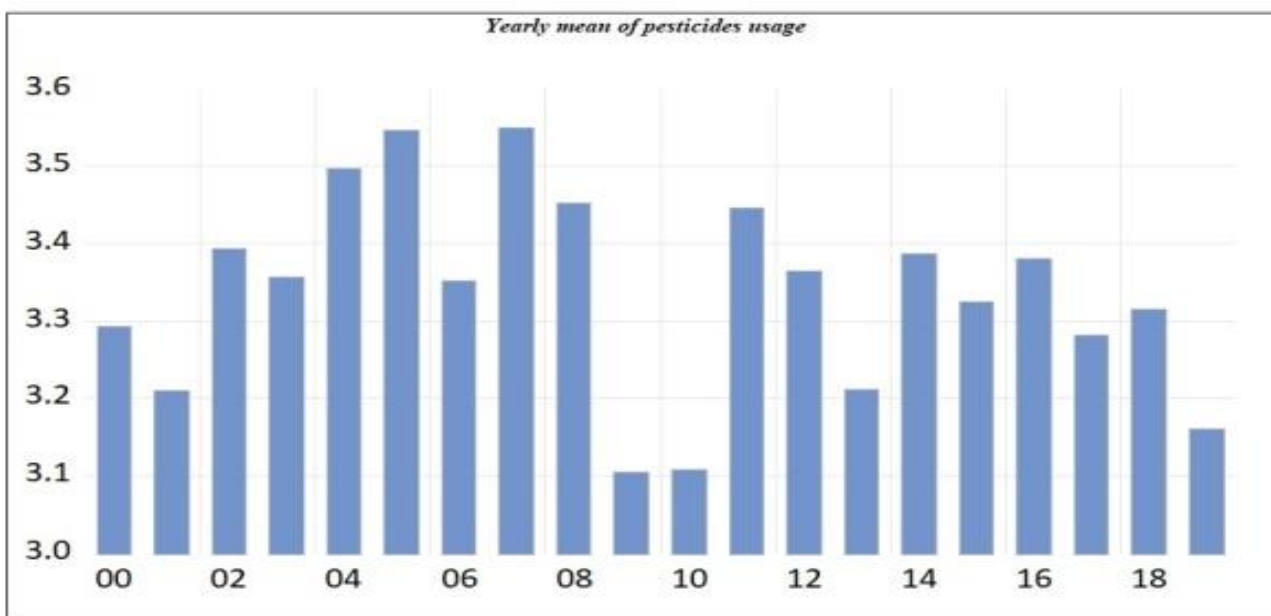


Figure 2- Pesticide usage yearly mean

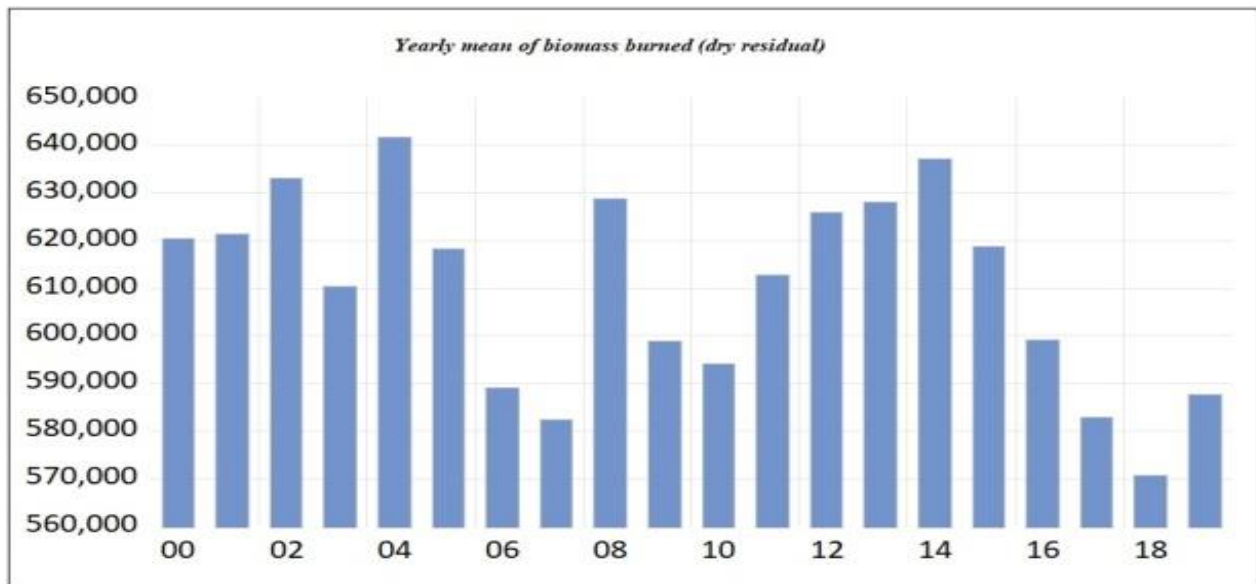


Figure 3 - Biomass burned yearly mean

Table 2 Summary statistics

Variable	Observations	Mean	Std Deviation	Min	Max
PM2.5	500	13.781	4.634	5.85	27.176
Pest	500	3.665	2.658	0.24	13.842
BMB	500	610076.1	871302.1	4406	3982668

Table 3, indicate that there is no multicollinearity exist among all the used variables as correlation coefficients are below 0.75

Table 3 Correlation Matrices

Variable	PM2.5	Pest	BMB
PM2.5	1.000		
Pest	0.051	1	
BMB	0.293	0.042	1

Table 4 Estimation

Variable	POLS	Driscoll-Kraay Fixed effect
Pesticide usage -(Pest)	0.051 (0.016)***	0.048 (0.026)**
Biomass Burned -dry residual-(BMB)	0.098 (0.008)***	0.012 (0.028)***
Constant	1.311 (0.109)***	2.785 (0.286)***
Observations	500	500
Number of groups		25

Table 4, reports the impact of pesticide usage and dry residual of agriculture biomass burn on fine particulate concentration (PM2.5) used as proxy for environmental sustainability. The

empirical estimation of analysis is done by using panel pooled OLS as mentioned in column 1 and then fixed effect Driscoll-Kraay estimation as mentioned in column 2. Column (1) shows that (Pest) and (BMB) positive increase pollutant particles in the environment. Result indicates that, a 1 unit increase in (Pest) and (BMB) increases PM2.5 by 0.051% and 0.098%. Similarly findings also indicate by Driscoll-Kraay Fixed effect estimation as mentioned in column (2); thus 1 unit increase in (Pest) and (BMB) increases PM2.5 by 0.048% and 0.012% respectively. The harmful effect of pesticide usage on environment sustainability proxied by PM2.5 also confirmed by previous studies such as (Coscollà et al., 2009; Fu et al., 2009; He et al., 2022). Likewise other studies which indicate similar harmful effect between agriculture residual biomass burning on environment were conducted by (Singh et al., 2021; Srivastava, 2022).

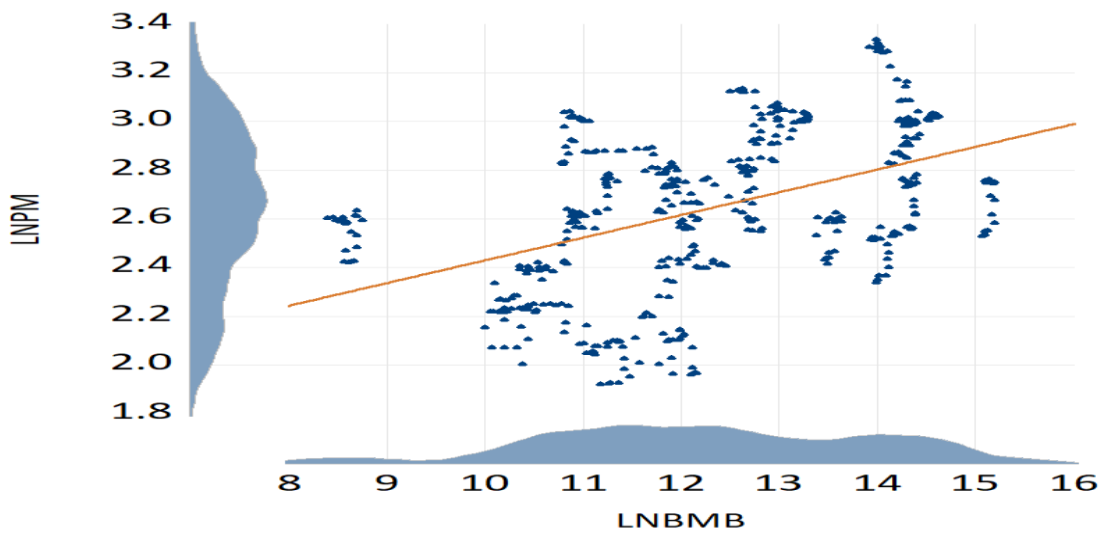


Figure 4 : Association between PM2.5 and BMN – LN refer to log transformation

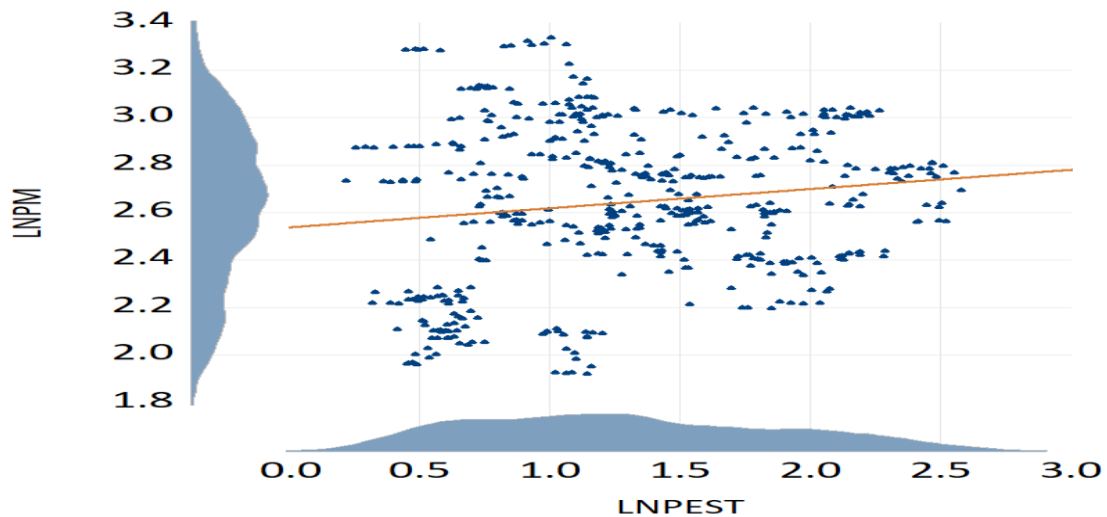


Figure 5 : Association between PM2.5 and PEST – LN refer to log transformation

CONCLUSION

To reduce greenhouse gas emissions by adopting sustainable production practices, this study aligns with the 2030 SDG agenda as the goal 2 and goal 13, which represent sustainable agricultural

practice and climate change. The empirical research work contributes to the debate on pesticide usage-agriculture biomass burning-environmental sustainability from the sample of 25 OECD countries from 2000 to 2019. Findings reveal that residual agricultural biomass burning and massive use of pesticides cause air pollution in the sample countries. Based on finds this research work, from a policy perspective, the government of sample countries should increase the awareness of adaptation of eco-friendly agricultural practices. Government should adopt sustainable waste management practices concerning residual agricultural biomass. Furthermore, the government should increase the usage of eco-friendly pesticides which not cause a high concentration of air pollution.

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