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## **POLLUTING TECHNOLOGIES AND SUSTAINABLE ECONOMIC DEVELOPMENT**

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In 2002 the city of Dortmund, located in the western part of Germany, was faced with one of the largest dismantling operations ever. Over a thousand Chinese workers, accompanied by engineers, started to cut up a huge iron and steel factory into millions of pieces. About 250,000 tons of iron, steel, electrical devices, and engines were then numbered, packed into boxes, and sent 9000 kilometers away to China, where the factory, piece by piece, was reassembled, intended to produce about 5 million tons of steel annually (Dohmen and Schmid, 'China-Town in Westfalen', *Der Spiegel*; April 8, 2002). While this particular example of the international movement of second hand capital goods is probably one of the more extreme ones, it is nevertheless demonstrative of how, while the market for used machinery and equipment is as old as that for new ones, it has only recently really boomed. For example, its growth rate has been characterized by double-digit figures in recent years, standing now at more than 150 billion Euros annually. Additionally, a simple search on the internet reveals the existence of dozens of auction houses, where objects sold range from simple tools to whole factories. Moreover, many more deals are not made directly at auction houses, but settled over the internet.

The bulk of the transfer of used machinery and equipment flows from the developed to the developing world and arguably has been an important impetus to economic growth in the latter. More precisely, lacking capital, many less developed countries can, via imported used capital goods, gain access to better means of production and thus avail of a low cost alternative to finance their growth. Additionally, it should be noted that older technologies are more labour intensive because they are less automated and often require greater maintenance. Coupled with the fact that absorptive capacities of new technologies depend on the skill availability of a country and that skilled labour is typically scarce in the developing world, developing countries thus make natural candidates for adopting these older types of machinery and equipment. In recognition of all of these factors, it has often been suggested that developing countries should reduce their barriers to trade on used machines and equipment, which often tend to be more stringent than for new ones.

Nevertheless, there are potentially also drawbacks to importing used rather new capital goods. Specifically, the question has been raised whether the transfer of vintage technologies to developing countries, particularly with respect to energy intensive capital goods, will promote sustainable development. In other words, if older technologies are, as is likely, more environmental unfriendly, then their advantages in terms lower capital costs and greater labour suitability may in the long term be more than counterbalanced by higher energy costs and pollutant emissions. Indeed, there is now clear evidence that carbon dioxide emissions have been steadily increasing in essentially all developing countries since the last century, and in some cases, such as China and India, have literally skyrocketed.<sup>1</sup>

Moreover, developing countries' continuing reliance on thermal energy and dirtier technologies to support economic growth is likely to further increase their pollutant emissions. In this regard, Janischewski et al. (2003) provide several real-world examples of environmental damages due to the use of older machinery and equipment. For instance, a

23 gigawatts fossil power station will cause about 2.2 billion tons of supplementary emissions of carbon dioxide compared to modern power stations. Similarly, a fleet of 300,000 used cars will cause additional 6,000 tons of nitrogen oxide and 70,000 tons of carbon monoxide compared to new ones.

Despite the potentially important role of the import of used machinery and equipment in the economic pollution-output relationship, there are virtually no studies in the academic literature that have examined this issue.

In the current paper we set forth to model how the decision to adopt older and dirtier technologies affects the relationship between economic development and pollution. In order to do so we build on a Schumpeterian framework by introducing a vintage capital structure, where the law of motion of environmental quality will depend on the pollution flow and some upper limit on environmental quality that takes into account the exhaustibility of resources. Importantly, and contrary to existing models, our vintage capital structure considers the decision of when to replace obsolete with newer technologies and how this may affect the pollution output relationship. If one assumes, as will be the case in our model, that older technologies are more environmentally unfriendly, then the decision of when to scrap these and what type of technology (i.e., used or new) to adopt is likely to be an important determinant of the extent of pollution generation.

Theoretical results of the model show that a reduction in environmental pollution during the industrialization process is only possible when the optimal rate of technological adoption has been reached. More importantly, the dirtier the adopted technology, the later a hypothetical reduction of the pollution-output ratio will occur. These theoretical predictions have potentially important empirical implications. In particular, there is no guarantee that countries will ever decrease their pollution-output ratio. But even in the particular cases when they will, this turning point will be postponed the older the adopted technology. Using data on output, carbon dioxide emissions, and US and EU exports of used machinery and equipment to a set of developing countries, we show that developing countries importing relatively more vintage technologies tend to reduce their pollution-output ratio at higher levels of output. Given that pollutants in general, and carbon dioxide emissions in particular, have very long lasting environmental effects, supporting the adoption of vintage technologies in developing countries today will arguably have repercussions in the very long run.

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<sup>1</sup> For instance, the growth of carbon dioxide emissions between 1990 and 1996 has been 2.4 per cent in France, 9.9 per cent in the US, compared to 40 and 47.7 per cent in China respectively India