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Analysis

The Environmental Impact of Sharing: Household and Urban Economies in CO_2 Emissions

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ABSTRACT

Studies find that per capita carbon dioxide (CO_2) emissions decrease with household size and urban density. The demographic trends of declining household size and dense urbanization therefore produce countervailing effects with respect to emissions. We posit that both household and urban economies are driven by proximity and realized through sharing carbon-intensive goods. With detailed data from the United States Consumer Expenditure Survey, we construct a dataset of CO_2 emissions at the household level and leverage a unique measure of residential density to estimate household and urban economies. Our estimates show that dense urban areas have per capita emissions roughly 20% lower than rural areas, and that adding an additional member to a household reduces per capita emissions by about 6%. We also find that household economies are about twice as large in rural areas as in dense urban areas and develop an explanation for this phenomenon. In theory, the carbon benefits of dense urbanization have the potential to offset the effects of declining household size. However, using historical US Census data and extrapolating from our estimates, we find that lost household economies have outpaced increased urban economies over the past fifty years.

1. Introduction

Studies frequently find that per capita carbon dioxide (CO_2) emissions are lower for people who live in multi-person households as well as for people who live in dense urban environments. We refer to these stylized facts as *household economies* and *urban economies* in CO_2 emissions. The former are analogous to economies of scale in production. If per capita income is held constant, then households exhibit economies of scale when increases in household size raise their members' utility. Empirical research finds that, holding per capita income constant, subjective well-being increases with household size (Rojas, 2007). Indeed, these economies of scale are taken for granted whenever equivalence scales are used to assign each household a value proportional to its needs based on its size and composition.[1] Economists attribute household economies to the existence of household public goods that are relatively non-rival in consumption. For example, housing, furniture, and appliances are shared by many household members. Consistent with this, analysis of the Consumer Expenditure Survey (CES) shows that households with more members tend to spend a smaller percentage of their income on household public goods (Salcedo et al., 2012).[2]

Recently, researchers have recognized that carbon-intensive goods tend to be household public goods. For example, residential energy and transportation are easily shared within households. Schröder et al. (2015) show that larger households tend to spend less on energy per person. Using expenditure data to calculate household carbon footprints, Underwood and Zahran (2015) find that per capita carbon dioxide (CO_2) emissions also decline with household size. These household economies in CO_2 emissions suggest that the trend towards smaller household size undermines the sharing of carbon-intensive goods within households, placing upward pressure on per capita emissions, and that people can reduce emissions by living together in large

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[1] The Organization for Economic Cooperation and Development (OECD) has used an equivalence scale that implies each additional adult needs 70% of that of a single adult, while each child needs only 50% of a single adult (OECD, 2013). More recently, both the OECD and the United States Census Bureau have used the so-called 'square-root scale' that implies, for instance, that a household of four persons has needs twice as large as one composed of a single person but does not distinguish between adults and children. The US poverty threshold assumes that additional household members (adults and children) need just 35% as much income as an adult living alone (US Department of Health and Human Services, 2016).

[2] However, empirical analyses of household expenditures are not always easy to reconcile with intuition. For example, Deaton and Paxson (1998) show that per capita expenditures on food decline with household size, even though food appears to be a private good.

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households (Ala-Mantila et al., 2014; Schröder et al., 2015; Underwood and Zahran, 2015).

Compared to household economies, urban economies in CO_2 emissions are widely studied but the empirical results are mixed. Many researchers have shown that national greenhouse gas emissions increase with the share of population living in urban areas (Jorgenson et al., 2014; Ponce de Leon Barido and Marshall, 2014), but this positive effect may depend on the level of affluence and stringency of environmental policy (Martínez-Zarzoso and Maruotti, 2011; Poumanyvong and Kaneko, 2010). Meanwhile, micro-level studies show that households in dense urban environments generate significantly lower CO_2 emissions than their rural counterparts (Glaeser and Kahn, 2010; Jones and Kammen, 2011; Shammin et al., 2010). However, not all urban forms have environmental benefits. Suburban households generally have higher emissions than both rural households and dense urban households (Jones and Kammen, 2014; Glaeser and Kahn, 2010; Ottelin et al., 2015). The mixed evidence for urban economies may arise from urbanization being a weak proxy for urban density.[3] Urbanization, a rising share of the population living in urban areas, does not itself guarantee the presence of urban economies, as it often reflects industrialization, suburbanization, and sprawl.

In this paper, we argue that cities generate urban economies by providing social and technological infrastructure that facilitates sharing. In other words, urban density reduces emissions by enabling the sharing of carbon-intensive goods *between* households, analogous to the sharing of goods *within* multi-person households. Both dense urban environments and large households reduce the share of carbon-intensive expenditures, driving per capita CO_2 emissions downward. As Glaeser and Kahn (2004) suggest, cities can be conceptualized as the absence of physical space between people. So, too, can large households. In multi-person households, members *successively* and *simultaneously* share the household and its energy requirements (Yates, 2016). Using the same kitchen and living room means that this space is used relatively more intensively. Sharing meals, television viewing, loads of laundry, and heating and cooling allows households to reduce per capita consumption of carbon intensive goods and services (Underwood and Zahran, 2015; Yates, 2016). Like households, cities enable individuals to *successively* and *simultaneously* share the built environment and its energy requirements. For example, dense housing allows households to share home heating and cooling via shared walls. Similarly, urban infrastructure, such as sidewalks, bike lanes, and public transportation, provide city dwellers with alternatives to travelling in private vehicles. Dense urban environments may also foster the inter-household sharing of private goods. Decentralized borrowing and lending of goods may become an increasingly important in the digital economy (Fremstad, 2016), and sharing-economy platforms tend to be most successful in cities where they can better match people with underutilized assets due to improved access (Yates, 2016).

Several studies have investigated the potential for significant rebound effects associated with the environmental benefits of dense urban areas. Agglomeration economies in dense urban areas generate wealth and yield savings that can be spent on other goods and services (Glaeser and Gottlieb, 2009; Heinonen et al., 2013a, 2013b; Wiedenhofer et al., 2013). It is possible that the emissions resulting from these expenditures will exceed the initial energy savings from urban density. For instance, Heinonen et al. (2013a) find that household expenditures and carbon emissions are highest in the Helsinski metropolitan area of Finland, compared to other cities, semi-urban, and rural areas. This is consistent with other studies showing that even when urban density yields lower private vehicle use and residential energy consumption, residents of large metropolitan areas (including suburbs) generate higher emissions than those in less dense areas (Jones and Kammen, 2014). In fact, Ottelin et al. (2014) find that emissions from air travel significantly offset the gains from reduced private transport in urban areas, especially among middle-income families in large metropolitan areas. Heinonen et al. (2013a) also show that the prevalence of summer cottages and second homes increases with urban density, in the case of the Helsinki metropolitan area. When controlling for differences in income, Heinonen et al. (2013b) find that per capita carbon footprints still fall with urban density, but only slightly. Importantly, this result is driven, in part, by smaller household sizes in dense urban areas and suggests that rebound effects do not entirely offset the initial urban economies. Since the savings from reduced expenditures on residential energy and private transport are likely to be spent on less carbon-intensive goods and services, this is the expected result (Underwood and Zahran, 2015; Wiedenhofer et al., 2013). Nonetheless, these rebound effects and "concurrent consumption of service spaces in different locations" are important considerations (Heinonen et al., 2013a).

In this paper, we address the environmental benefits of sharing carbon-intensive goods by estimating household economies and urban economies in a single model, net of any rebound effects. Our work builds on Ala-Mantila et al. (2014) which documents both household economies and urban economies in CO_2 emissions in and around Helsinki, Finland. Drawing on Ala-Mantila et al. (2016) we also investigate the interaction between these two effects. We move this research forward in three ways. First, we estimate our model using data from the Consumer Expenditure Survey, which provides a nationally representative pooled cross-section of household carbon dioxide emissions in the United States (US) from 2012 to 2014. Second, we develop a conceptual framework to make the case that household economies and urban economies are both the result of a similar mechanism: the sharing of carbon-intensive goods. Importantly, this allows us to develop an explanation as to *why* urban economies may have the potential to substitute for household economies. Third, we use our estimates to quantify the countervailing effects of declining household size and urbanization on US per capita CO_2 emissions over the last fifty years. In doing so, our paper sheds light on the extent to which increased urban density is likely to offset the declining household economies resulting from the demographic drift towards more and smaller households.

In the next section, we describe our method of calculating CO_2 emissions at the household level and our model for estimating household and urban economies. In Section 3, we present our results and test their robustness to several model specifications. Section 4 discusses the implications of our findings, including what they suggest about the magnitude of the increased urban economies and lost household economies in the US over the last fifty years. In Section 5, we conclude with some limitations to our analysis, suggestions for future research, and policy implications.

2. Data and Methods

This paper uses detailed expenditure data to estimate CO_2 emissions at the household level. Using data from the US Consumer Expenditure Survey (CES) from 2012 to 2014 we construct a nationally representative pooled cross-section of American households. The Interview Survey, used here, captures approximately 85–95% of household expenditures.[4] Each household can appear in the survey for no more than four consecutive quarters. CES Interview Survey data on household expenditures cover 14 broad categories: food, alcoholic beverages, housing, apparel, transportation, healthcare, entertainment, personal care, reading, education, tobacco products, cash contributions,

[3] Liddle (2013), for instance, finds that the correlation between national population density and urban density is relatively low (0.35) and that national urbanization levels are actually negatively correlated with urban density.

[4] The Interview Survey does not collect expenses for very frequently purchased items such as housekeeping supplies, personal care products, and nonprescription drugs that account for around 5 to 15% of expenditures.