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Are compact cities environmentally friendly?

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ABSTRACT

There is a wide consensus among international institutions and national governments in favor of compact (i.e. densely populated) cities as a way to improve the ecological performance of the transport system. Indeed, when both the intercity and intra-urban distributions of activities are given, a higher population density makes cities more environmentally friendly because the average commuting length is reduced. However, when we account for the possible relocation of activities within and between cities in response to a higher population density, the latter may cease to hold. Indeed, an increasing-density policy affects prices, wages and land rents, which in turn incentivizes firms and households to change place. This reshapes the urban system in a way that may generate a higher level of pollution. Thus, although an increase in compactness is environmentally desirable when locations are given, compactness may not be environmentally-friendly when one accounts for the general equilibrium effects generated by such a policy.

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1. Introduction

According to Yvo de Boer, former Executive Secretary of the United Nations, "Given the role that transport plays in causing greenhouse gas emissions, any serious action on climate change will zoom in on the transport sector" (speech to the Ministerial Conference on Global Environment and Energy in Transport, January 15, 2009). The transport sector is indeed a large and growing emitter of greenhouse gases (GHGs). It accounts for 30% of total GHG emissions in the US and approximately 20% of GHG emissions in the EU-15 (OECD, 2008). Within the EU-27, GHG emissions in the transport sector have increased by 28% over the period 1990–2006, whereas the average reduction of emissions across all sectors is 3%. Moreover, road-based transport accounts for a very large share of GHG emissions generated by the transport sector. For example, in the US, nearly 60% of GHG emissions stem from gasoline consumption for private vehicle use, while a share of 20% is attributed to freight trucks, with an increase of 75% from 1990 to 2006 (Environmental Protection Agency, 2011).[1]

Although new technological solutions for some transport modes might allow for substantial reductions in GHG emissions (Kahn and Schwartz, 2008), improvements in energy efficiency are likely to be insufficient to stabilize the pollution generated by the transport sector (European Environment Agency, 2007). Thus, other initiatives are needed, such as mitigation policies based on the reduction of average distances travelled by people and commodities. To a large extent, this explains the remarkable consensus among international institutions as well as local and national governments to foster the development of *compact* (or densely populated) *cities* as a way of reducing the ecological impact of cities and contributing to sustainable urban development. Nevertheless, the analysis of global warming and climate change neglects the spatial organization of the economy as a whole and, therefore, its impact on

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[1] This increase is associated with an increase in the average distance per shipment. In France, from 1975 à 1995, the average kilometers per shipment has increased by 38% for all transportation modes, and by 71% for road transport only (Savin, 2000). Similar evolutions have been observed in the richer EU countries and in the USA.

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transport demand and the resulting GHG emissions. It is our contention that such neglect is unwarranted.

A large body of empirical literature highlights the effect of city size and structure on GHG emissions through the level of commuting (Bento et al., 2006; Kahn, 2006; Brownstone and Golob, 2009; Glaeser and Kahn, 2010). The current trend toward increased vehicle use has been reinforced by urban sprawl, as suburbanites' trips between residences and workplaces have increased (Brueckner, 2000; Glaeser and Kahn, 2004). Kahn (2006) reports that the predicted gasoline consumption for a representative household is lowest in relatively compact cities such as New York and San Francisco and is highest in sprawling cities such as Atlanta and Houston. While the environmental costs of urban sprawl are increasingly investigated in North America, the issue is becoming important in Europe as well. For example, between 1986 and 1996 in the metropolitan area of Barcelona, the level of per capita emissions doubled, the average trip distance increased by 45%, and the proportion of trips made by car increased by 62% (Muniz and Galindo, 2005). Recognizing the environmental cost of urban sprawl, scholars and city planners alike advocate city compactness as an ideal.[2]

According to the urban compactness proponents, a higher population density makes cities more environmentally friendly because the average commuting length is reduced. We confirm this view as long as both the intercity and intra-urban distributions of activities are given. That said, we want to stress that the latter assumption is typical of a partial equilibrium analysis. In the present context, such an analysis fails to account for the fact that a higher population density is likely to spark the relocation of firms and households. Indeed, because an increasing-density policy affects prices, wages and land rents, it is reasonable to expect firms and households to change places in order to re-optimize profits and utility. Accounting for these general equilibrium effects makes the impact of higher urban density ambiguous, the reason being that the new spatial pattern need not be better from the environmental viewpoint. Therefore, *a full-fledged analysis of an increasing-density policy must be conducted within a general equilibrium framework in which firms and households' locations are endogenously chosen between and within cities.*

Furthermore, once it is recognized that the desirability of increasing-density policies depends on the resulting spatial pattern, another question comes to mind: which spatial distribution of firms/households minimizes transport-related GHG emissions in the space-economy as a whole? Transporting people and commodities involves environmental costs which are associated with the following fundamental trade-off: concentrating people and firms in a reduced number of large cities minimizes pollution generated by commodity shipping among urban areas but increases pollution stemming from a longer average commuting; dispersing people and firms across numerous small cities has the opposite effects. Therefore a sound environmental policy should be based upon the ecological assessment of the entire urban system. Although seemingly intuitive, this global and general equilibrium approach has not been part of the debate on the desirability of compact cities.

That said, the above trade-off also has a monetary side, and thus an increasing-density policy has welfare implications that are often overlooked by compact cities' proponents. This should not come as a surprise because transporting people and commodities involves both economic and ecological costs. In other words, there is a tight connection between the ecological and welfare objectives. According to Stern (2002), the emissions of GHG are the biggest market failure that the public authorities have to manage. It is, therefore, tempting to argue that deadweight losses associated with market imperfections are of second order. This view is too extreme because a higher population density impacts the consumption of *all* goods, and thus changes individual welfare. Having this in mind, we show that increasing density may generate welfare losses when the urban system shifts from dispersion to agglomeration. For this reason, our paper focuses on both the *ecological* and *welfare* effects of a higher population density when firms and households are free to relocate *between* and *within* cities.

In doing so, we consider the following two urban scenarios. In the first one, cities are monocentric while consumers and firms are free to relocate *between* cities in response to a higher population density. We show that an increasing-density policy may generate a hike in global pollution when this policy leads the urban economy to shift from dispersion to agglomeration, or vice versa. For example, when both the initial population density and the unit commuting cost are low enough, an increasing-density policy incentivizes consumers and firms to concentrate within a single city. However, at this new spatial pattern, the density may remain sufficiently low for a single large city to be associated with a longer average commuting, which generates more pollutants than two small cities. Conversely, when the unit commuting cost is high, the market leads to the dispersion of activities because consumers aim to bear lower land rent and commuting costs. Yet, when the density gets sufficiently high, the average commuting is short enough for the agglomeration to be ecologically desirable because intercity transport flows vanish. Consequently, agglomeration or dispersion is not by itself the most preferable pattern from the ecological point of view. In other words, *our results question the commonly held belief of many urban planners and policy-makers that more compact cities are always desirable*. They also show that one should pay more attention to the effect of increasing-density policies on city size.

In the second scenario, we study the ecological and welfare impact of an increasing-density policy when both the city size and morphology are endogenously determined. By inducing high urban costs, a low population density leads to both the dispersion and decentralization of jobs, that is, the emergence of polycentric cities. If urban planners make the urban system more compact (i.e. raise population density), then, the secondary business centers shrink smoothly and, eventually, firms and households produce and reside in a single monocentric city. We show that these changes in the size and structure of cities may generate higher emissions from commuting. Thus, an increasing-density policy should be supplemented with instruments that influence the intra- and inter-urban distributions of households and firms. In particular, we argue that a decentralization of jobs within cities, that is, a policy promoting the creation of secondary business centers, both raises welfare and decreases GHG emissions. Although we acknowledge that the transition from a monocentric to a polycentric pattern generates wasteful commuting, the fact that similar workers are paid significantly more in central business districts than in secondary business centers suggests that such wasteful commutes do not wash out the lower costs and rents associated with secondary centers (Timothy and Wheaton, 2001).

In what follows, we assume that the planner chooses the same population density in all cities. Alternatively, we could assume that city governments noncooperatively choose their own population density. Both approaches have merits that are likely to suit countries with different attitudes regarding major issues such as the development of more densely populated cities. Our main argument is that the planning outcome is typically used by economists when assessing the costs and benefits of a particular policy.

The remainder of the paper is organized as follows: In the next section, we present a model with two monocentric cities and discuss the main factors affecting the ecological performance of an urban system. While we acknowledge that our model uses specific functional forms, these forms are standard in economic theory

[2] See Dantzig and Saaty (1973) for an old but sound discussion of the advantages of compact cities. Gordon and Richardson (1997) provide a critical appraisal of this idea.

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