Environmental Policies Benefit Economic Development: Implications of Economic Geography

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Abstract

For over a century, starting with the work of Alfred Marshall (and including in resource economics), economic geography has emphasized the productivity of dense urban agglomerations. Yet little attention goes to one key policy implication of economic geography's core mechanisms: Environmental policies can aid economic development, *per se*—not hurting the economy to help the environment but advancing both objectives. We review mechanisms from economic geography which imply that environmental policies can deliver such win-wins: influences upon agglomeration of long-standing natural conditions, like usable bays, which long were perceived as fixed yet now are being shifted by global environmental quality; agglomeration's effects on other influential conditions, like urban environmental quality; and the effects of rural environmental quality on the flows to cities of people and environmental quality. Finally, we consider a geographic policy typology in asking why society leaves money on the table by failing to promote environmental policies despite the potential win-wins that we highlight.

1. INTRODUCTION

The field of economic geography links spatial patterns in growing economies and nations' rates of economic development, with policy recommendations. Three spatial mechanisms that affect growth are highlighted: economies of agglomeration, with increases in total productivity when firms locate in dense urban centers; migration, especially when households tend to move into the most productive cities in search of higher wages and lower prices; and specialization, where regions of distinct advantage focus upon their best sectors and then trade for other goods.

Productive urban clusters are also shaped, however, by the interplays of agglomeration with congestion – given that the total number of people, plus their mixes of types or expertises, affect urban economic performance. The importance of lowering transport costs and other hurdles to movements is implied by these points. Thus, the economic-geographic literature has tended to suggest policies which facilitate labor and goods flows.

With different policy foci, resource and environmental economists have long used such ideas. Earlier and more generally, Marshall (1920) argued that physical conditions such as soil quality, climate, and water availability affect the location of industries. Locational fundamentals theory has continued such assertions that the spatial heterogeneity of natural endowments is a major determinant of development patterns, through locations of concentration. Many later repetitions of such ideas (e.g., Ellison & Glaeser 1999) highlight that cities often began as ports, based on access to transported goods. In this very journal, Irwin et al. (2009; see also Irwin et al. 2010) review causes and impacts for urban land-use patterns at multiple scales, then consider policies that seek to manage urban growth. Also in this journal, Wu (2019) reviews the drivers of agglomeration as well as views about agglomeration's impacts on environmental quality.

We focus on the impacts of environmental quality, with implied potential for environmental policies to have net economic benefits. That the net economic costs for environmental policies could be negative has not been emphasized in economic geography (yet see parts of Wu 2019), but it follows from multiple mechanisms. First, natural endowments affect spatial optima, including spatial organizations and productivities of activities. That imply roles for policy because, globally, humans now shift such long-standing and influential natural conditions (e.g., sea levels are rising globally as one consequence of climate change). Second, pollution that is generated locally congests cities, thereby choking off productivity. It can be shifted by policies. Third, the rural degradation of nature affects rural quality of life – and thus also urban migration, as well as urban quality of life, including through water quality and floods. It too is affected by environmental policies. These policy implications in economic geography are due to the impacts of environmental quality. Put another way, the full economic impact of environmental policies includes any economic gains implied by the general equilibrium of a landscape. The adoption of environmental policies might increase if their net pro-economic implications were better known.

We structure this review around those mechanisms from economic geography, spelling out the mechanisms and their environmental policy implications. They follow the initial thinking in new economic geography, which illuminated the gains from urban density, and trade, in light of agglomerative forces (Fujita et al. 1999, Krugman 1999). Uneven distributions of economic activities over space are suggested by centripetal and centrifugal forces that affect citizens' and firms' location decisions, driving economic outcomes as well as shaping policy impacts. Early efforts explained stylized facts concerning firms' agglomerations in big urban centers, using a taste for variety, or increasing returns, to shed light on the roles of agglomerative and dispersive forces. Yet, as their complexity was difficult to bring to data, recent developments in trade with quantitative spatial models (Redding & Rossi-Hansberg 2017) facilitate empirical examination of impacts on economic development from transport investments, migration restrictions, and trade liberalizations. Furthermore, empirical links of geography and the environment have started to appear in, e.g., a well-established sorting literature that intersects urban and environmental economics (Kuminoff et al. 2013).

We stress environmental perspectives that imply complementary policies and also can add to the logic underlying optimal versions of the policies typically of interest in economic geography. Putting the local, regional, and global environmental externalities from degradation of nature into the core models of economic geography—as below (or in Wang & Wu 2011)—does not dispute but rather builds upon their underlying logics: Lowering externalities can raise welfare, given output, but also can allow more productive agglomerations.

Section 2 draws on the existing literature to sketch a model that summarizes core economic geography while permitting us to highlight the multiple roles of nature. Sections 3 reviews three mechanisms which allow for environmental policies to have net benefits for the economy, and thus win-wins alongside environmental gains: how natural resource and environmental quality, globally, influences investments in agglomeration; how urban quality of the environment is a (sometimes endogenous) force of dispersion, utilizing local air pollution as one globally relevant example; and how rural environmental quality affects urban quality—and thus also productivity.

Section 4 spells out economically beneficial roles for environmental policy that are implied by these mechanisms. Finally, as our goal is to highlight underrecognized economic benefits of environmental policy (policy often rejected by those focused on economic outcomes, perhaps in ignorance of these benefits), Section 5 borrows further from literature focused upon economic-development outcomes, including on the basis of economic-geographic thinking. The World Bank's *World Development Report of 2009* (WDR09) utilized economic geography to make a case for certain policies (World Bank 2009). It also offered a spatial policy typology that we draw upon in asking why societies might fail to implement the win-wins asserted here.

2. THE ROSEN–ROBACK MODEL

To fix ideas for readers unfamiliar with this literature, we present a version of the Rosen–Roback model of consumer location (Roback 1982), widely used to illustrate the effects of amenities and environmental factors upon consumers' and workers' location decisions (see Wang & Wu 2011 for a treatment of amenities and city formation and Kuminoff et al. 2013 for review of applications to housing markets). Consider a consumer who enjoys nontradable amenities (A), consumption goods (C), and housing (H). Subject to a budget, consumers select from all the locations $j \in \{1, \ldots, J\}$ to maximize indirect utility V, which will be a function of r, the cost of housing; p, a price index of consumption; and w, the wage.

$$V\left(A_j, r_j, p_j, w_j\right) \geq V\left(A_k, r_k, p_k, w_k\right) \forall k \neq j. \qquad 1.$$

Economic geography stresses two influences on location decisions: transport costs, affected by distance and legal barriers, here denoted τ; and population density, n. In each location, transport costs (τ) affect prices by changing the costs of shipping to that location. Transport also affects wages within these locations, as those costs affect the degree to which each location's firms could access labor currently in other locations.

Population affects the cost of housing (r) through competition for housing; i.e., more people drive up r. Amenities may rise with population for low ranges of n, reflecting positive consumption externalities or agglomeration. Amenities may fall with n for high ranges, as local amenities or public goods suffer from congestion. Wages rise with productivity and thus with population, given positive production externalities [$\theta(n)$, here general Marshallian externalities (not industry-specific)]. Wages can fall with population for higher ranges if there exist congestion effects on production, as when commuting time is lost in traffic.

Amenities may often suffer from congestion at lower population densities than those which can reduce production, implying a range in which *A(n)* is decreasing while $\theta(n)$ is still an increasing function of *n*. Equation 2 includes these relationships between population, transport costs, and sites' indirect utilities:

$$V\left[A(n), r(n), p(\tau), w\left(\theta(n), \tau\right)\right]. \qquad 2.$$

An equilibrium consists of a vector of amenities, rents, prices, and wages for which no agent is willing to move given others' location choices. If populations are mobile, the equilibrium for such a sorting or location-choice model requires rents to adjust to equalize indirect utilities across locations. Thus, populations are endogenous, as those areas with higher amenities and higher real wages will feature higher populations, reflecting indirect utility in that location and the vector of other locations, plus the land in each location. Thus, the optimal amount of population within location *j* can be written using the following expression:

$$n_j\left(V_j, L_j, \bar{V}, \overline{L}\right). \qquad 3.$$

Resulting stylized predictions relate to economic-geographic policy recommendations:

1. Density of population raises productivity and wages for a range of *n*, in turn increasing population, reflecting positive production spillovers and thus agglomeration economies in successful cities.
2. Lower transport costs and fewer movement hurdles raise real wages, increasing populations, particularly in more productive, higher-wage urban centers, with rural areas losing people overall.
3. Urban amenities suffer from congestion as populations rise. With externalities, private choice by migrants may not be socially optimal. Thus, *n* could be too high, creating roles for interventions.

Next, we add an exogenous environmental-and-natural resource element, *e*, as well as endogenous environmental quality that shifts with *n*, $q(n)$. Thus, we write an individual's indirect utility in the form shown in Equation 4:

$$V\left[A\left(n,q\left(n\right),e\right),r\left(n\right),p\left(\tau\right),\ w\left(\theta\left(n,q\left(n\right),e\right),\tau\right)\right]. \qquad 4.$$

We presume that amenities *A* rise with *q* and *e*, while *q(n)* is a decreasing function of *n*, reflecting a negative environmental externality associated with a greater population density. Productivity θ is positively linked to *q*, creating a negative production externality if *n* increases to the point that it negatively impacts *q*.

The equilibrium now depends upon nature, in several ways. To start, the initial endowment of amenities will depend on exogenous environmental elements such as coastlines, climate, and abundant natural resources. Additionally, any pollution externalities impact the desirability of different regions, introducing new pathways for potential congestion. Finally, environmental quality can affect locations' productivities and, therefore, wages (see Chang et al. 2016 on California pear packers).

These considerations add to the stylized predictions resulting from such an economic geography model. They suggest environmental guidance and policies for urban areas and for rural areas with urban links:

4. Natural resource constraints affect local productivity, and in turn optimal density, guiding policy globally to support and locate investments in agglomerations with positive production spillovers. We summarize related literature in Subsection 3.1 and environmental policy implications in Subsection 4.1.
5. Urban environmental degradation becomes endogenous congestion that limits agglomeration. Thus, optimal urban policies include pollution regulations that raise quality of life and population densities. We summarize related literature in Subsection 3.2 and environmental policy implications in Subsection 4.2.
6. Degradation of environmental amenities affects sites' desirability, locally and through spillovers. Across influential rural areas its spatial patterns differ and shift with migration and investments. We summarize related literature in Subsection 3.3 and environmental policy implications in Subsection 4.3.

3. UNDERLYING ECONOMIC GEOGRAPHY

3.1. Mechanism 1: Natural Conditions Influence Agglomeration & Shift with Global Environmental Quality

Here we review three distinct mechanisms, from economic geography, which have some form of our key implication that environmental and resource policies can benefit economic development.

3.1.1. Natural constraints on production (agglomeration and trade within manufacturing and agriculture).

Geographic variations in natural features and constraints, such as coastlines and mountains, have long played significant roles in shaping the sizes and densities of cities. For example, Saiz (2010) finds that constraints on developable land due to water bodies and slopes lead to lower housing supply elasticities, driving up housing prices within the constrained cities. Moreover, the resulting spatial differences can get entrenched due to long-term population dynamics in which the relative growth rates of cities builds upon initial underlying natural advantages, such as ports and rivers, instead of supplanting them. In other words, the ranks in size across cities within a country appear to be determined by key geographic factors such as water sources and trade opportunities, whereas the degrees of differences between ranks are determined by specialization and agglomeration due to increasing returns (Davis & Weinstein 2002, Krugman 1991). Henderson et al. (2017) extend such thinking in finding links between climate and urbanization, differentiated links depending on whether cities export manufacturing or service rural areas.

Geography also plays a significant role in the specialization in agriculture and the responses in agriculture and manufacturing to transport shocks between regions that trade. Historically, coastal and border areas are centers for producing exports (Kerem Coşar & Fajgelbaum 2016), as they feature lower transport costs. Yet natural endowments and infrastructural investments can, in principle, overcome this when natural inputs for producing an export lie inland. In the United States, populations retreated to cities on coasts, and on rivers, when the Northeast region was connected by new railroads with the more agriculturally productive Midwest region (a similar evolution occurred in Australia). Uneven natural endowments also shaped local responses to the new transport infrastructures. For the US East Coast, as the Midwest's agricultural advantage led the East to focus on manufacturing, points along rivers with waterfalls, and thus natural power for industries, were the recipients of internal migrants (Pfaff 2001).

Soil and rainfall differences that favor agriculture can have lasting effects on agricultural productivities, economic growth, and population, even in the presence of changing technology. Hornbeck (2012a) finds that the fundamental geographic advantages of farmland preserved the ranking of land value in the United States, even as technology raised agricultural productivity across the board. Productivity differences are similarly central in Sotelo (2019)'s analyses of Peruvian agriculture, in which regional differences in agroecology established the baseline productivities that determined lasting comparative advantages, even as trade and transport improve farmers' ability to specialize based on their underlying advantages.

Such differences are likely to shift with global environmental quality, however, with key implications for urban areas and for agriculture. Climate change has the potential to rearrange comparative advantages between regions and cities. Areas closer to the Earth's poles may well become more attractive for agricultural production, while tropical weather patterns seem likely to be disrupted. Such climatic changes may even neutralize prior strong coastal advantages. For instance, previously favorable coastal sites for cities and trade may increasingly be inundated.

Desmet & Rossi-Hansberg (2015) simulate economic impacts of climate change over 200 years, finding damages concentrated near the equator. Trade restrictions interact with the lack of climate mitigation, preventing regions from adapting via trading patterns. Migration restrictions would also interact, exacerbating regional inequality with a wedge between wages in regions more versus less vulnerable to climate change. Desmet et al. (2018) estimate that removing migration restrictions globally could triple global total welfare by allowing movements toward opportunities in growing regions where agglomeration economies are strong. Climate damages are higher due restrictions on adjustments to newly efficient patterns of populations and land uses (Desmet & Rossi-Hansberg 2015). Costinot et al. (2016) examine evolving comparative advantages in agriculture at the global level under different climate scenarios, using the Global Agro-Ecological Zone data from the UN Food and Agricultural Organization with information on expected agricultural production before and after climate change. Testing counterfactuals in their general equilibrium model, they find that adjustments in what farmers grow substantially mitigate negative impacts of climate change. These studies on long-run adaptations to climate change emphasize value from mitigation and adaptation, as individual responses to changing environmental conditions may have a large effect on the realized damages of climate change.

3.1.2. Natural constraints on connective infrastructures.

Nature has long played key roles in where people have invested to lower their costs of transport.

Investments in ports are unsurprisingly focused on coasts to facilitate export (Kerem Coşar & Fajgelbaum 2016) and they respond to natural variations, such as where bays offer protection from storms, or where greater depths permit big ships (Fujita & Mori 1996). In turn, investments in roads follow, in part, from port locations: Moving goods to ports for export, and moving imports from ports, have long been a central feature of development for many economies.

Shocks that are locally exogenous (even if globally endogenous), such as sea-level rise or extreme storms with surges and rains, interact with locally rationale spatial-economic dynamics. Damages from shocks are amplified by the rational concentration of investments in coastal cities. Coastal infrastructure faces a spatial trade-off: to profit from the relatively higher current returns from investing in the coastal centers of population that reflect long-standing natural constraints or to shift now to avoid facing costly adjustments in the future.

Along these lines, Balboni (2019) focuses on Vietnam, with a dynamic spatial equilibrium model to study infrastructure investments during 2000–2010. Given the possibility of climate change and its subsequent future inundation risks, she finds that coastal favoritism in investment has had a significant cost. Transport investment that avoided the most vulnerable regions could have raised welfare 72% under the central scenario for sea-level rise.

Desmet et al. (2018a) develop a similar model to consider such issues at a global level, examining how sea-level rise could affect the world economy, while taking into account the dynamics of migration, trade, and investment in local technology. They find that under an intermediate scenario of greenhouse gas emissions, global real gross domestic product (GDP) would decline by 0.19% (in present discounted value) between 2000 and 2200. Yet behind this average effect, they find important heterogeneity across countries. For example, according to their model, real GDP would decline by more than 7% in both Vietnam and Thailand.

3.2. Mechanism 2: Agglomerations Constrain Themselves by Degrading Urban Environmental Quality

Dense cities arise as firms and individuals co-locate to enjoy the benefits of positive production externalities and the increasing that returns they generate (Krugman 1991). Yet each migrant to a dense city also contributes to negative congestion externalities, such as traffic, while firms add pollution externalities. This can deter further migration (more below) unless policy is undertaken to mitigate negative externalities. Wu, Segerson & Wang (2021) support the potential economic effectiveness of environmental regulation, noting (as we do) the classic arguments that urban diseconomies, such as traffic congestion and air pollution, can be major centrifugal forces for decentralization (see Fujita & Thisse 2002, Glaeser 1998, Henderson 1974). Fundamentally, the growing cities in emerging economies generate high levels of particulate pollution with not only global costs from their carbon emissions but also local costs for their own citizens (Kahn 2009).

To fully harness their potential for agglomeration, cities and regions must address all of the externalities associated with urban growth and transportation. Particulate levels are associated with shortened lives (Chen et al. 2013), for instance, due to effects on infant mortality (Chay & Greenstone 2003). Low particulate levels are also highly valued by consumers, as evidenced by preferences for housing with better air quality (Bayer et al. 2009). Air quality policy is a part of encouraging urban growth that can raise productivity. Cleaning up unpleasant and unhealthy pollution allows high-skill workers to congregate in cities, raising productivity and income.

The influence of environmental conditions on urban densities is evident in research on urban amenities and, e.g., high-skill workers. In the United States, temperate climate is associated with higher population growth and in-migration, contributing to economic growth in Sun Belt cities with climates more pleasant than so-called legacy industrial cities in the Northeast and Midwest (Glaeser et al. 2001). Nearer to the equator, though, higher temperatures increase out-migration, on average (Timmins 2007). Bayer et al. (2009) find such amenity effects for air quality as well, with higher urban housing prices for higher air quality.

Evidence from China links air quality degradation to economic growth, which has relied on the productivity of urban centers. Significant externalities generated under little regulation of air pollution are detracting from the welfare of urban residents. This externality affects optimal migration while also influencing growth via effects on workers' rates of productivity. Both particulate emissions and rising temperatures can damage labor productivity, even for the workers who toil indoors (Chang et al. 2016, Zhang et al. 2018, Zivin & Neidell 2013).

3.3. Mechanism 3: Rural Environmental Quality Affects Migration, Mobile Pollution, and Agglomeration

Literature on environmental factors affecting urban density often focuses on their effects upon migration. Some environmental factors may push people away from certain locations, such as climate shocks to agricultural productivity in rural areas, while other environmental factors may pull migrants to other locations. Of course, international and internal migration features multiple drivers (Arango 2017), including variations in political stability, satisfaction of basic needs, and incomes. Still environmental conditions may also be significant factors in either direction, noting an estimated several million environmental migrants today and possibly orders-of-magnitude increases in the future (International Organization for Migration 2009, Rigaud et al. 2018).

Our previous discussion of urban environmental quality clearly featured potential impacts upon migration. Any urban environmental issue, such as particulate levels, could be either a push out of or a pull into any urban area, depending on its relative level: People depart dirtier places but move toward cleaner ones. Here, we focus instead upon rural environmental quality, which also has impacts on both rural and urban denizens.

In considering rural resources and environments, commentators certainly have supported the idea that natural resource scarcities (Hunter 2005, Hunter et al. 2005) and poor environmental conditions (Hunter 2005) can significantly shift populations (Lee 1966, Todaro 1969), albeit in a variety of ways, in light of complex social-ecological interactions (Black et al. 2011). Those with natural resources (e.g., higher agricultural productivities) are more likely to be able to invest in long-distance migration, as in rural Ecuador (Gray 2009a, 2010) and northeastern South Africa (Hunter et al. 2014). In many regions of Africa, migration in response to climate shocks spurred urbanization for regions where cities have significant industrial activity. In less-industrial areas, options to migrate to nonagricultural livelihoods do not exist, limiting adaptation (Henderson et al. 2017).

Of course, migrations have historically played important roles in adaptation to shifts in natural resources and the environment, for example, during the Irish potato famine, the invasion of cotton boll weevils in the US South, or the severe dust storms that took place in US and Canadian prairie regions during the 1930s (Cook et al. 2009). These historical experiences suggest that migration sometimes could offer an effective adaptive strategy for households facing environmental pressures, such as those which appear to be increasing due to climate change.

Rising temperatures have increased internal migration in Brazil, Uruguay, and South Africa (Mastrorillo et al. 2016, Thiede et al. 2016). Low rainfall drives both domestic and international migration in rural Mexico, especially from areas depending on rain-fed agriculture (Leyk et al. 2017). Crop failures driven by lower rainfall have also fueled migration in Bangladesh (Gray & Mueller 2012), which is often involuntary environmental migration (Hunter et al. 2015). Acute events like natural disasters (Fussell et al. 2014, Lu et al. 2016) and chronic events like drought (Bates 2002, Hugo 1996, Renaud et al. 2007) all can lead to involuntary migration. Moreover, shocks to rainfall and soil quality or quantity (i.e., erosion of topsoil) can affect long-term rates of economic growth (Dell et al. 2014) and, in turn, regional levels of populations (Hornbeck 2012b). The latter is seemingly linked with rural-urban migration (Marchiori et al. 2012).

Sorting models, with population movement between cities, highlight the potential roles for migration in mitigating negative effects from increases in temperatures or particulate pollution (Bayer et al. 2009, Timmins 2007). Such adjustments seem likely for future climate adaptations. For example, observed reductions in recent rainfall in some locations have already been found to contribute to rates of rural-urban migration within Africa (Henderson et al. 2017). Naturally, not all such resource shocks can be affected by local policies, yet they illustrate nature's importance.

The consequences of environmental shocks that lead to migration are not uniform across social groups, which in turn can have consequences for overall productivity: not everybody fares the same in cities. The degree to which mobility aids household adaptation depends on, e.g., the sensitivity of livelihoods to climate (Warner & Afifi 2014). The poorest households may most be trapped by exogenous environmental shifts, as they may lack capital −including scarce natural capital − and be unable to send a household member elsewhere to send back remittances (Black et al. 2011). In the 1990s and 2000s, poor households were unable to use migration to respond to local floods in Bangladesh (Gray & Mueller 2012). The poorest households also suffer higher exposures to climate-related environmental hazards, with fewer alternatives for settling in safer places. Owing to relative immobility, they endure more severe and long-lasting consequences (Blaikie et al. 1994, Gray 2009b, Gray & Mueller 2012, Gutmann & Field 2010, IPCC 2007).

Considering the roles of non-environmental policies, governmental barriers to migration can limit responses to such shifts in environmental conditions. Internal migration restrictions within a country are perhaps less common, although significant frictions do exist. China regulates internal migration using residence permits (*Hukous*) that restrict access to public services outside one's official residence. That might lower welfare (Au & Henderson 2006) − yet be supported by the residents of growing cities, who may prefer to restrict rural-urban migration to limit congestion (in light of global modeling, such as by Desmet & Rossi-Hansberg 2015, we note that political economy of restrictions clearly also applies to various limitations on international migration).

In the United States, policy has slowed rural-urban migration, given the trend toward more stringent zoning and building codes in major cities (Glaeser et al. 2001). Restrictions were not randomly located but responded to local congestion and homeowners' incentives, with the most restrictive regulations concentrated in the highest-earning cities on the coasts (Gruber & Johnson 2019). Such restrictions in major cities might be locally justified by environmental externalities. Yet they may have a negative environmental impact when looking across a region by shifting the new building to less-energy-efficient areas (Glaeser & Kahn 2010). If so, then pro-density policy in places with lower environmental externalities might be beneficial from both an economic-geographic perspective and an environmental-economic perspective on limiting emissions.

4. ENVIRONMENTAL POLICIES WITH ECONOMIC BENEFITS (AS IMPLIED BY ECONOMIC-GEOGRAPHIC MECHANISMS)

Each of the three subsections below spells out implications for gains from environmental policy that follow from the corresponding subsection above about mechanisms in economic geography. Our organization of sub-sections follows the "geographic policy typology" proposed in WDR09.

4.1. Mechanism 1's Enviromental Policy Implications: Spatially Blind and Global Climate Mitigation with Targeted Adaptation

Beyond local externalities described below, coastal cities are threatened by greenhouse gases emitted worldwide. Many large cities are vulnerable to sea-level rise, given concentrations along coasts guided by exogenous natural features thought to be fixed. To avoid climatic and sea-level changes, the leading efficient policy would be spatially blind, i.e., applied everywhere given the externalities' global nature. For instance, emissions could be taxed globally at rates equal to the external costs from each pollutant, leading emitters to internalize costs of their pollution and thereby incentivize abatement measures. Such a policy can be designed without regard to the details of the location of emitting sectors and firms. That is ideal for global pollutants, as then abatement would be undertaken by firms with the lowest cost [though, generally, the mobility of pollution facing taxation can be a concern (Wu & Reimer 2016)].

Such policies for improving local, regional, and global environmental quality generate economic cost, all else equal: taxation that internalizes the full cost of production lowers production levels. The critical geographic point here, however, is that within the general equilibrium of a landscape, all else is not equal – e.g., productivity is not if environmental externalities are so large as to disperse urban agglomeration. One need not even place value on environmental quality, *per se*, to adopt environmental policies in order to eliminate *economic* externalities. Those policies raise environmental quality given output but also increase output.

Adaptation investments, in contrast, are more targeted to where global climate forecasting suggests the need, given likely climate impacts. Optimal bundles surely combine gray (sea wall, drainage system, and bridge) with green (restored wetlands, transitional zones, inland retreats) investments where effective (Hill 2015). Such policies require coordination across administrative levels and they might also clash with existing policy plans. Yet considerable efforts will almost certainly be merited, as changes in climate reshape the coastal landscape. For instance, Balboni (2019) finds significant welfare improvements from reallocating transportation infrastructure to take into account future coastal inundations. Similar studies are needed to understand all of the economic implications of climate adaptation. The re-optimization of infrastructure investments, given changing natural conditions, is likely to be one key urban policy in the coming decades.

4.2. Mechanism 2's Environmental Policy Implications: Improving Upon Urban Environmental Quality Yet for Economic Reasons

Effects of lower environmental equality motivate political responses, e.g., concerning air quality (Zheng & Kahn 2013), as costs of pollution as a centrifugal force—depressing housing demand and in-migration–are not fully born by polluters. If private spatial equilibria are suboptimal, it motivates policy to curb externalities, in order to promote density in urban agglomerations.

Addressing the pollution in cities is becoming a political imperative as large populations in urbanizing middle-income countries such as China are entering the middle class and demanding improvements in quality of life (Zheng & Kahn 2013). This demand for pollution abatement is one proposed mechanism to explain the inverted U-shape, known as the environmental Kuznets curve, which has characterized the relationship between pollution and income over time within most wealthier countries. Whether this pattern holds widely for emerging economies, however, is still an open question (Harbaugh et al. 2002), thus improving air quality should not be seen by policy leaders as automatic as incomes rise. Instead, pollution mitigation should be a conscious goal of policy making, for local environmental quality and to realize gains from agglomeration.

Urban environmental policy certainly can lower emissions. Actors in China have succeeded in reducing pollution in growing cities (Zheng & Kahn 2013), yielding hopes for environmental Kuznets curve patterns at least in urban areas. This might induce additional migration to cleaner cities. In this journal, for instance, Wu (2019) points out that such urban pollution standards, if successful, can make agglomeration cheaper by limiting negative pollution externalities from new individuals and firms. Enforcement can support such difference in growth. In the United

States, counties not in attainment with pollution standards may be limited in expansion, at least in investments (Greenstone 2002). Migration to cleaner cities after such a policy might yield the same urban pollution as without that policy, however (Wu, Segerson & Wang 2021 highlight the environmental effects of the positive economic feedback from any initial gains), yet such policies still could improve welfare, as more production would occur for any given level of externalities.

Wu et al. (2021) note agglomeration can lower costs of both compliance with environmental regulation, as larger markets may have easier access to required information and technologies, and government enforcement itself—but also that in turn lowered externalities can increase the agglomeration, which while productive can increase pollution concentration in the long run. Wu & Wu (2012) empirically examine interactions between air-quality regulation and agglomeration economies in seven air-polluting industrial sectors in the United States. Based on data collected from 1998 to 2014, the authors find that regulation reduces plant births in nonattainment areas, for some industrial sectors, yet in enhancing the effect of agglomeration economies encourages births, for a minimal total impact. Wu et al. (2021) find similar results for the control of water pollution in China.

Such environmental policies could also have larger landscape-level effects. Kyriakopoulou & Xepapadeas (2017) derive optimal spatial equilibria with local production externalities, finding that without externalities, a monocentric city would be optimal, but with them, a dual peak with two less-dense areas can be optimal. A social planner could use a Pigouvian tax on polluters. Glaeser et al. (2005) offer a mechanism, based on local voters, that raises housing costs via zoning regulations on developers and spreads cities outward while limiting migration into heavily regulated cities. Saiz (2010) endogenizes policy response by noting that homeowners in geographically land-constrained cities pay higher prices already. Therefore, they have more of their net worth at risk in local housing markets and incentive to advocate for zoning restrictions that may shield them from any downside risks of denser development in their neighborhoods.

Glaeser & Kahn (2010) note that at a regional scale, such a local policy could have the effect of raising regional emissions by pushing development to areas whose political economy favors fewer restrictions. That could increase residences in regions with higher average energy usage. Generally, land-usage restrictions driven by local congestion can have substantial implications for locations, labor, and growth. Restrictions on building height in Indian cities, e.g., intended to keep density down out of a fear of overcrowding infrastructures, tended to spread development, increasing driving times and total pollution (Brueckner & Sridhar 2012). Decisions at too small a spatial scale can be socially suboptimal.

Irwin et al. (2009) also review comments on land-use restrictions as urban resource policies with environmental impacts. Early analysis based on the monocentric model argued that, in the absence of other market failures, not-too-stringent urban growth boundaries forcing cities to be more compact can be second-best to congestion tolls (Brueckner 2002, Pines & Sadka 1985). Yet, when allowing employment to be dispersed, with households making both residential and employment location decisions, Anas & Rhee (2006, 2007) find limits on the conditions under which urban grown boundaries are welfare increasing. Contrary to the monocentric result that optimal congestion tolls would reduce the spatial extent of cities, even efficient tolling might cause additional suburbanization when employment is dispersed because some households may reduce their commuting distances by choosing suburban employment. Under such conditions, Anas and Rhee conclude that constraints on cities' growth outward would be welfare reducing. Such discussion of policy in landscapes with high flows of people segues to our next mechanism.

4.3. Mechanism 3's Environmental Policy Implications: Intervening to Affect Rural-Urban Flows of Both Pollution and People

At a landscape scale, one policy alternative to zoning or land-use restrictions within large cities could be subsidies to being less-populated areas. If the production externalities are strongest for high-skill occupations, then Rossi-Hansberg et al. (2019) state efficient policies would subsidize low-skill workers to move to smaller cities. That could alleviate congestion while still allowing for occupational clusters of the higher-skilled workers. Policy makers already make transfers to lagging regions via federal subsidies to local public goods (e.g., free internet) and might justify that in terms of inefficient levels of congestion in growing high-tech clusters. Environmental policies that keep rural regions less polluted could, then, in principle be part of such a plan.

4.3.1. Environmentally connective infrastructures: eco-payments to affect flows of pollution and people.

If environmental quality itself flows from rural to urban areas, such as if water quality in cities is affected by practices upstream, or rural agricultural burning affects urban air quality, there may be gains from rural environmental policies that, given flows, also are effectively urban policies. There may be gains to trade, if areas offer subsidies to assure that environmental damages do not flow to cities. That is precisely the motivation for a growing suite of new institutions, worldwide, for payments from urban to rural areas conditioned on flows of eco-services [e.g., conservation of erodible land in agriculture (Xu et al. 2010) or limits on agricultural run-off into rivers such as preserving private forest land (Jayachandran et al. 2017) or for species habitats creating private reserves (Smith & Shogren 2001)]. While their impacts have not always been high (Pattanayak et al. 2010, Robalino & Pfaff 2013), if urban interests are sufficient transfers can benefit all parties.

Beyond that direct environmental connection are indirect environmental-economic linkages. As rural inhabitants need to drink and breathe, their ability to do so in current rural areas affects decisions to move to cities. As discussed in Section 2, any institution that raises rural welfare not only advances on that element of the United Nations' Sustainable Development Goals but also could improve agglomeration's productivity by lowering any inefficient rural-urban migrations.

4.3.2. Environmentally adjusting typical investments in economic-geographic connective infrastructures

The World Bank's WDR09 publication advocated density, distance and division policies given economic-geographic logics (World Bank 2011). Yet well-developed literatures have shown that environmental degradation is associated with all of: urbanization; transportation infrastructure; and trade. Thus, economic impacts resulting from degradation of environmental quality (global, urban, rural as in Section 3) could drive redesign of geographic (urbanization or trade) policies.

To start, optimal urban density may be lower, given environmental issues (e.g., air quality). As productive as agglomeration may be, local congestion of environmental quality may lower productivity and optimal city size (Kyriakopoulou & Xepapadeas 2017). Putting it another way, assuming that some significant level of pollution from industry is just a given, states might adjust industrial policy to facilitate investment in new agglomerations versus in current sites (perhaps one such example is the recent announcement that the capital of Indonesia will be relocated).

Also, environmental externalities reach beyond the locality in which they were generated, so unwelcome arrivals of pollution motivate adjustments of geographic policy. Instead of focusing only minimizing transport costs, policies might also consider discouraging negative spillovers. Given pollution flows, as well as for considering inefficient rural-urban migration, in general it is possible that prior optimal economic-geographic policies should be adjusted for the environment.

4.3.2.1. Adjust migration-relevant policy given degradation of environmental quality?

Migration can have positive or negative environmental effects on areas receiving as well as areas sending migrants (Adamo & Curran 2012, Curran 2002, Fussell et al. 2014, Unruh et al. 2004). In sending areas, depopulations may improve environmental outcomes, e.g., allow regrowth of forest on abandoned land (Aide & Grau 2004, Oldekop et al. 2018). Yet if this were to hinder the continuity of existing natural-resources and environmental governance, then it could hurt nature, especially within areas facing high local pressure on resources and environment (Merino 2012).

For rural sending areas, remittances are among the most consequential results of migration – yet their effects can go either way. Remittances may reduce resource dependence by substituting bought goods for production (Jaquet et al. 2016) or external funds can have deleterious effects by expanding damaging practices, e.g., by transforming agricultural land into (peri-) urban parcels for real-estate development (de Sherbinin et al. 2008, Meyerson et al. 2007).

Rural departures to urban areas can be 'win-win' if cities thrive while rural degradation falls. Farms and whole regions have been abandoned to forests. Yet if rural crops must feed the same total populations, rural-urban migration may not be sufficient to reduce extensive agriculture – and if migration raises urban incomes, total food demand could rise, in particular for meat and other nonstaple food goods. Thus, *a priori* the net effects on the environment are not at all clear.

Rural areas that receive migrants also may incur effects upon their environments and natural resources. Arrivals to sites with high-value amenities can increase degradation, e.g., when labor density rises in mining, agriculture and/or ranching (Joppa et al. 2009, Wittemyer et al. 2008). Relocation of farm workers to cassava fields within Thailand (Curran & Cooke 2008), as well as settlement of displaced individuals within northern Darfur in The Sudan, are linked with lower vegetation given expanded small farming (Hagenlocher et al. 2012). Migrations also can affect environmental attitudes in receiving areas (Hunter 2000, Merino 2012, Robson & Berkes 2011).

4.3.2.2. Adjust trade-relevant policy given degradation of environmental quality?

Trade between regions with differing environmental protections can increase the degradation where protection is lower and even increase total degradation (Chichilnisky 1994). Pollution evidence is mixed. Some pollution havens with less regulation attract firms (Chen et al 2016, Greenstone 2002, Wagner & Timmins 2009), yet factor endowments and agglomeration effects may dominate locations (Antweiler et al. 2001). Trade's impact varies with capital, as well as agglomeration, so openness may not drive pollution. Some regions specialize in capital-intensive or higher-polluting industries. For example, some evidence suggests that trade openness reduced pollutants within Latin America but yet raised pollution in Asia (Kleemann & Abdulai 2013).

Recent studies find land conversion and deforestation owing to trade. For agriculture, some evidence links trade to forest loss; e.g., Leblois et al. (2017) suggest that trade in agricultural commodities accounts for a significant share of deforestation in low-income countries. Abman & Lundberg (2019) find that regional trade agreements link to deforestation for those countries that previously imported food. Alix-Garcia et al. (2018) find a similar pattern in Europe after the 1850 Austro-Hungarian Customs Union.

Yet linking regions with different levels of productivity could generate environmental benefit alongside economic gains from trade, if it displaces resource-intensive production within newly importing regions. Tombe (2015) builds a multisector model of agricultural trade in the spirit of Eaton & Kortum (2002), finding that trade costs reduce welfare mainly via a nonoptimally high share of employment in agriculture. Thus, trade openness could spur a structural transition in the economy, away from agriculture, as has enabled land sparing in many if not all contexts.At least for forest transitions, Meyfroidt et al. (2010) find empirically that increased demand for imported timber negates about half of the resource-sparing effects from ceasing extensive local land uses.

4.3.2.3. Adjust transport-relevant policy given the degradation of environmental quality? Partial equilibrium empirical studies of roads, at least within the most highly studied contexts, have long associated roads with deforestation and fragmentation of natural habitat (Busch & Ferretti-Gallon 2017; Chomitz & Gray 1996; Kaimowitz & Angelsen 1998; Pfaff 1999, 2007). This is relatively robust for Latin America from the 1980s to the present, for example, although broad averages can mask significant heterogeneity in impacts depending on topography (Hoyos et al. 2018), population (Cropper et al. 2001), wealth (Li et al. 2013), and the local conservation policies (BenYishay et al. 2016). If impacts of roads are heterogeneous across a landscape, that can be critical for optimal investments. The impacts of new roads on Brazilian Amazon forests varied with prior economic development (Pfaff et al. 2018). Such variation is also seen across contexts within India and, supporting that point, average impacts for more densely developed India are lower than those for the Brazilian Amazon (Kaczan 2020). Roads linking cities may have higher economic gains, due to the productivity of urban agglomerations, as well as lower environmental costs. Spreading populations widely, using transport, may well be a lose-lose.

Some transport impacts present more spatially idiosyncratic factors in optimal investments, such as the effects on species habitats that might be unique, not compensated by gains elsewhere. Dasgupta & Wheeler (2016, 2018) include habitat and biodiversity impact in their spatial impact evaluations that encourage place-based policy adjustments, if damages are spatially specific as they can be for biodiversity hotspots (Hughes 2019). These issues are salient for infrastructure. China's Belt and Road Initiative supports transport investments worldwide, and Hughes (2019) has estimated that 15% of biodiversity hotspots in Asia are within 1 km of a planned Belt and Road Initiative infrastructure route, raising the possibility of high losses of biodiversity if routes are not shifted (Losos et al. 2019) to avoid high environmental damages. Transport planning is one opportunity for regional strategic environmental planning. Implementation and frameworks for strategic environmental assessments have been proposed by the United Nations Environment Programme, the World Bank, and many others (Abaza et al. 2004, World Bank 2011).

General equilibrium studies highlight that lowering transport costs can redistribute economic activities. For example, Donaldson (2018) finds that rail transport in India lowered trade costs, thus shifting land use and raising trade and incomes. Sotelo (2019) studies how lower transport costs, plus a price shock, affect agricultural trade using a model with heterogeneous land quality where farmers sell commodities across Peru and internationally. Paving appears to raise average productivity by 8% via specialization and use of better inputs. Porteous (2019) uses grain prices in Sub-Saharan Africa to estimate a dynamic model of trade in agriculture, suggesting that lower transport costs would greatly increase welfare by reducing food prices. This is driven largely by the greater adoption of technologies, i.e, transport could shift productivity and, thus, patterns of land use. Shifts in trade following transport investments could dominate local resource impacts. When railroads connected the US East Coast to the more agriculturally productive Midwest, Eastern forests did not vanish but instead increased, as the East Coast then imported agriculture. In New England, farmers moved to cities (Pfaff & Walker 2010). Understanding local impacts upon the environment due to this important rail connection involves landscape adjustments.

5. DISCUSSION: WHY NOT ALWAYS ADOPT THESE POLICY WIN-WINS ?

The World Bank's WDR09 (World Bank 2009) utilized economic geography to make the case for certain policies of the types just discussed, i.e., their density, distance and division policies, which we just argued could be adjusted by adding environmental to economic-geographic logic. In categorizing policies that affect density, distance, and division, WDR09 also offered a spatial typology that we drew upon above in separating policy implications for Section 4's subsections. We draw on it here in asking why society may fail to implement the win-wins we have asserted.

Thinking geographically, the WDR09 suggests that one might distinguish blind, targeted, and connective policies. Spatially blind policies simply apply everywhere, as we suggested for global carbon taxes in Section 4.1. Spatially targeted policies instead aim at specific locations that have particular features both long-standing and endogenous. The endogeneity of relevant features is highlighted for climate adaptation, aimed at climate change's impacts in Section 4.1, as well as for urban policies. aimed at local agglomeration impacts in Section 4.2. Long-standing features arise in Section 4.3 with the importance of historical communities within migration and unique species habitats. Spatially connective policies link sites. Thus, if environmental quality flows over landscapes, as discussed in Section 4.3, then both complementary environmental policies and environmental adjustmenst to typical economic-geographic policies are connective policy.

This typology is useful for predicting the adoption versus non-adoptions of win-win policy. Who gets the benefit when any actor adopts a costly policy will, of course, affect its adoption. Naturally, actors should adopt policies with net benefits in their own regions. That seems most likely for spatially targeted actions, such as climate adaptation or urban air quality regulation. It is not surprising, then, that worldwide we observe local investments of both of those types.

We might also expect to see spatially connective analogs. For instance, if rural environmental policy is effectively urban environmental policy as well, since it lowers the flows of damages to cities, we expect urban willingness to pay. Indeed, many cases show that downstream actors are willing to incentivize behavior upstream and even to head upstream to organize institutions. Yet the need to connect regions raises potential breakdowns in negotiations to establish and maintain agreements. While cross-national Coasian transfers do happen, despite negotiations challenges, perhaps establishing connections between upstream regions within nearby counties is easier.

We hardly need to highlight the collective-action challenges of spatially blind policies, in the global sense, such as are involved in the coordinations regarding policies for climate mitigation. Those facing the economic costs, such as those who reinsure valuable coastal capital, are starting to stress economic gains from maintaining environmental quality (or at least degrading it less). However, because for any one country most of the gains from adopting a high carbon tax flow elsewhere, the wait goes on for spatially blind environmental policy that is truly transformative.

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