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Review

A review of community impacts of boom-bust cycles in unconventional oil and gas development

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A R T I C L E I N F O

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A B S T R A C T

Unconventional oil and gas development (UOGD) has become the most widespread form of energy production in the United States. The booms and busts associated with UOGD are not unique to the industry, but the impacts to local communities are. As the industry continues to dominate the nation's energy landscape, and marginalized communities are disproportionately exposed to the extraction processes, it is important to understand the full scope of the environmental and social impacts experienced by communities during booms and busts. We review the literature on both the ecological and social boom-bust impacts of UOGD, noting the dearth of research on bust-time impacts. We conclude by calling for greater research on the long-term impacts of busts, in particular, and on understudied aspects of social impacts like those to public services, infrastructure, and social capital.

1. Introduction to unconventional oil and gas booms and busts

How do booms and busts impact natural resource-rich communities? In the mid-2000s, introduction of drilling technologies like high-volume hydraulic fracturing (often called fracking) created the phenomenon termed *unconventional oil and gas development* (UOGD). UOGD encompasses a suite of approaches that made it economically viable to mine oil and gas trapped in deep underground shales [1]. This innovation caused oil and gas production to boom in the United States, but excess production in 2015 caused prices to drop, sending oil and gas companies into bankruptcy [2]. Despite a brief recovery from 2017 to 2019, the COVID-19 pandemic caused another drop in prices and concomitant industry losses [3].

The rapid growth of an extractive industry, or *boom*, can stimulate a local economy but bring with it problems such as environmental degradation and infrastructure damage. During a *bust*, when the extracted resource is exhausted or demand for it falls, economic gains tend to dissipate and affected communities are left the same or worse off [4]. UOGD boom-bust cycles mirror those experienced throughout history by communities with coal, mineral, and conventionally accessed oil and gas reserves (e.g., [5]). After constructing and developing a well site for drilling, actual production typically involves a smaller labor force employed over a longer period [6], meaning that many industry jobs are limited to the initial development period [4,7].

When UOGD becomes uneconomical, operators idle or abandon wells. Oil and gas workers leave for other opportunities, decreasing a community's available labor force [8]. The service sector tends to shrink, property values decline, and unemployment and poverty increase [4]. Government revenues and funds dwindle, and investment and business opportunities disappear [4]. Residents, particularly those who moved in during the boom, may relocate if they can afford to do so [9]. Boom-bust communities often end up poorer and with slower economic growth than comparable communities that did not experience a boom [4,5,10].

This paper examines the range of local consequences of UOGD booms

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and busts in the United States. While several papers review community impacts from UOGD, most have a rather narrow focus on a single type of impact, like environmental [11–14] or economic [15]; few assess both biophysical and socioeconomic consequences of UOGD. Moreover, this scholarship almost universally focuses on booms [9,16,17].[1] To address this knowledge gap, we summarize the research on community impacts of both booms *and* busts in unconventional oil and gas development in the United States, with a focus on biophysical *and* socioeconomic dimensions. We begin by explicating what is known about the conditions communities experience during booms (moving through environmental, economic, infrastructure, public health, public services, housing and social capital impacts, in that order) and then busts (in the same format); we then offer suggestions for future research, highlighting the need for attention to human impacts and bust conditions.

To collect relevant articles, we queried Google Scholar and Web of Science[2] for references containing a UOGD-related term (unconventional oil and gas, hydraulic fracturing, and fracking) and an impact term (boomtown, bust, economic, environmental, public health, public service, infrastructure, housing, and social capital impacts). To account for differences in algorithms that computerized bibliographic databases may produce and to capture as many relevant articles as possible, the searches were duplicated by four separate researchers. We collected articles from the first three result pages of Google Scholar as those are considered the most salient [20]. Eligible articles had to be peer-reviewed, empirical investigations of the impacts of UOGD in the United States. Given the importance of geographic and sociopolitical dynamics for shaping boom-bust cycles [21], we decided to limit our review to domestic boom-bust literature focused on UOGD so that we could maximize the applicability of our findings to the U.S. context.

Our search yielded 192 unique publications included in this review. Across the literature, we found an emphasis on UOGD boom-times, with only 34 publications discussing one or more bust-related impacts (Table 1). Topically, most studies examine environmental impacts (85 articles), followed by public health (43 articles). The least discussed impacts include public services (18 articles) and social capital (21 articles).

In the remainder of this paper, we first synthesize the literature on environmental and social impacts of UOGD in the United States during booms and busts. We then situate this review within a broader discussion of opportunities for government intervention into UOGD boom-bust cycles. Finally, we conclude our article with suggestions for future research.

Table 1
Summary of literature reviewed on U.S.-centric UOGD boom-bust impacts. Because a publication may focus on booms, busts, or both across one or more impact types, the total sum of the cells is greater than the 192 unique publications included in the review.

Impact type	Boom-focused articles	Bust-focused articles	Total articles by impact
Economic	21	12	33
Environmental	76	9	85
Housing	20	3	23
Infrastructure	26	2	28
Public health	40	3	43
Public services	16	2	18
Social capital	18	3	21
Total articles by boom or bust	217	34	

2. Boom-time community impacts

2.1. Environmental impacts

The total environmental impacts of unconventional oil and gas development are estimated at $162,000 to $755,000 per well, owing predominantly to methane leakages, habitat fragmentation, and diesel use by trucks and pumps [22]. UOGD releases air pollution from machinery involved in extraction as well as from transportation, distribution, and use of hydrocarbons. The heavy truck traffic needed to equip a well site releases particulate matter, nitrous oxide, dust, and other compounds [23]. UOGD processes emit particulate matter [24], radioactive particles [25], volatile organic compounds, and BTEX chemicals [26], and increase the production of ground-level ozone [27]. Relative to conventional wells, unconventional wells have more embodied carbon - they consume 90 % more energy throughout the supply chain, though this is offset by increased productivity of unconventional wells [28].

UOGD releases two major greenhouse gases, carbon dioxide and methane [23,29]. In Colorado, for example, roughly 4 % of extracted gas is lost to the atmosphere during drilling, transmission, and distribution [30]. UOGD's methane emissions are particularly concerning given methane's high global warming potential, though the actual amount of methane emitted is subject to debate [31–35]. Early research showed that between 0.05 % [36] and 8 % [31] of methane from UOGD escapes over a well's lifetime. More recent work found that fugitive methane emissions range from 2.8 % to 17.3 % [35]. Seven well pads in this region averaged 34 g of methane emissions per well, almost three times the emissions expected by initial estimates [35].

UOGD impacts water resources during well pad development, water acquisition, chemical mixing, hydrocarbon production, and wastewater treatment and disposal [11,37]. Hydraulic fracturing involves injecting a highly pressurized mixture of water, propants, and chemicals into shales, propagating fractures through which oil and gas can flow. A hydraulically fractured well requires between 1.7 and 8.7 million gallons of water, averaging around 5.2 million [32], with substantial regional variation [38]. The per-well rate of water use is accelerating across nearly all U.S. shale plays, increasing by up to 770 % between 2011 and 2016 [39]. In some regions, like Dallas, Texas, water used for UOGD accounts for 9 % of total water use [40]. Many areas where UOGD occurs in the U.S. are water-stressed or would become water-stressed if extraction were to occur, putting UOGD in competition with other water demands [41].

Water is mixed in a proprietary blend with sand and other chemicals[3] [42] (e.g., surfactants, volatile organic compounds) [43,44], then injected into wellbores. Defective well casings or faulty equipment can spill or leak this fluid into surface waters or groundwater [45–47]. In four U.S. states heavily engaged in UOGD, 2–16 % of wells experienced spills annually, with 50 % of spills related to fluid transportation and storage [48,49]. Surface waters have been negatively impacted by well pad development, with sediment runoff increasing nitrogen and phosphorous loads [37] and drilling itself increasing acidity of stream water [50]. A growing body of literature finds adverse impacts to microbial communities in streams and other headwaters, such as decreased species diversity [50,51].

Groundwater aquifers can be exposed to chemicals and gases if

[1] There is an international literature that has explored boom-bust life courses (sometimes referred to as boomtown dynamics) with a focus on socioeconomic impacts (see for example Ruddell and Ray 2018's analyses of resource-based boom communities [18] or in the larger energy development space Perez-Sindin 2021 [19]); we see this as a fruitful avenue for future analyses of U.S. UOGD booms and busts.

[2] We used a subset of the same search terms on ScienceDirect and JStor and could find no additional articles so decided not to use any other search engines or expand the search any further.

[3] As of 2011, at least 632 different chemicals were used in these proprietary solutions [42].

fractures induced in shale formations connect to natural faults or other existing pathways [52], and through surface spills of chemicals [53]. For example, home drinking water wells in close proximity to drilling operations (within 1 km of in Pennsylvania and 3 km in Texas) have significantly higher methane levels [54–56] than more distant homes, likely due to well integrity problems. Groundwater becomes contaminated with greater total organic carbon, and pH changes as UOGD increases in an area, indicating the presence of contaminants [57]. This groundwater contamination varies geographically [58] and topographically, generally greater in valleys and near wells [59]. Releases of certain pollutants, such as methane, may lead to underground chemical reactions (e.g., loss of oxygen and conversions of sulfates to sulfides) that result in air and water pollution [54].

Some proportion of the injected fluid returns to the surface as wastewater, or *produced water*. Between 2005 and 2014, U.S. UOGD produced more than 250 billion gallons of wastewater [60]; from 2011 to 2016, wastewater from U.S. wells in their first year of production increased up to 550 % [39]. Total wastewater from the Marcellus Shale region increased 570 % from 2004 to 2013 as a result of UOGD in the area [61]. This wastewater often contains salts, heavy metals, and radioactive materials that can contaminate soil and water [62,63]. At the start of the U.S. UOGD boom, wastewater was often transported to local treatment facilities ill-equipped to manage it. Insufficiently treated wastewater, in turn, was linked to increased electric conductance in streams and negative impacts to aquatic organisms [64], prompting development of federal pretreatment standards [65].

Currently, UOGD wastewater is treated onsite and reused, stored and transferred to off-site locations, or injected into deep wells [65,66]. Deep well injection is often more economical than other disposal methods [67], but can threaten surface and groundwater quality [44,68–70] and trigger seismicity [67,71,72]. Since the early 2010's there has been a significant increase in seismicity in Eastern states, with roughly 10–33 % of hydraulically fractured wells producing detectable seismicity [73]. While both drilling and wastewater disposal can trigger seismicity, wastewater disposal is linked to higher maximum seismic magnitude [73].

Noise, odor, and light pollution arise directly from UOGD activities (e.g., flares and burn-offs) [74–77] and indirectly via increased truck traffic [78,79]. While truck traffic abates somewhat after initial construction of wells and infrastructure, in the longer term, pervasive but more subdued noise is generated by well pumping and compressor stations [80]. Light pollution from well pads and well flaring can negatively impact nearby residents. Pennsylvanians living near UOGD wells report needing to adjust living patterns (e.g., closing the windows and blinds) to sleep because of nighttime light from UOGD [81], and UOGD-associated increases in light pollution appear connected to inadequate sleep and degraded health [76,82]. In a survey of a homeowners living near UOGD facilities in Pennsylvania [83], more than 80 % of respondents reported experiencing UOGD-related odors sometimes or constantly [83]. Thirty-four percent of Louisiana residents interviewed about impacts from Haynesville Shale development reported concern about odor, noise, dust, and light [84].

UOGD booms can also negatively impact wildlife and ecosystem services. Increased human activity in and around well sites, as well increased truck traffic and infrastructure development, can disrupt wildlife migration [85], expand the wildland-urban interfaces, increase risk to threatened and endemic species [86,87], introduce invasive and disturbance-adapted species [80], and fragment existing habitat [88,89]. Construction of access roads and other UOGD infrastructure may damage root systems, resulting in loss of topsoil and siltation into local water systems [90]. Ecosystem services such as water provisioning, timber production, food production, and biodiversity conservation have been negatively impacted by UOGD habitat fragmentation and land conversion [91].

2.2. Economic impacts

As oil and gas operators moved into shale-rich areas in the U.S. in the mid-2000s, they were accompanied by an influx of workers. For every 10 % increase in earnings in a U.S. county during the boom, its population averaged a 1.1 % increase in population growth [8]. Sale and property tax revenues increased for state and local governments with shale resources [92]. These increases in workers and revenue, combined with investments from oil and gas companies, helped expand local service sectors, infrastructure, and economies [4,93].

UOGD creates job opportunities in the oil and gas industry and supporting sectors, increasing employment, income, and local wages [94–98]. Direct jobs result from exploration, drilling, and production; and indirect jobs result from increased demand for inputs like concrete, electricity, vehicles, and fuel [99], as well as hospitality, recreation, administration, and retail [10]. In Pennsylvania alone, UOGD brought 46,000 jobs from 2004 to 2013 [98]. Wages in U.S. counties experiencing UOGD booms (2000−2010) increased up to 10 %, while certain industries, like food and accommodations, saw a 17 % increase [6]. Early in the U.S. boom, the number of completed wells was positively associated with an increase in per-capita income [100]; and counties with high-intensity UOGD saw wage increases of 5–22 % [8].

Workers in oil and gas or adjacent sectors, and landowners receiving royalties and lease-signing bonuses, often boost local sales tax revenues by spending earnings locally [99]. During the recent boom, each one million dollars in new oil and gas production in a U.S. county yielded roughly $80,000 additional wage income and $132,000 additional business and royalty income [101]. The UOGD industry also produces revenue for local governments from oil and gas property taxes [92] and (potentially) portions of state-collected production taxes or impact fees [102]; localities also might directly earn income by leasing their public lands for drilling.

These economic benefits are often temporary, however, due to market volatility, the finite nature of the resource, and reduced oil and gas employment needs following the initial development “pulse” [4,101]. Booms disproportionately benefit shareholders and those in oil and gas industry management rather than on-the-ground production workers [96]. Many UOGD jobs go to out-of-state workers with more relevant training than locals [4,8,103]; jobs in UOGD-associated industries (e.g., trucking) tend to be part-time, short-term, and low wage [10]; and positive employment effects do not always spill over into non-mining sectors [93,99,104–106]. Non-oil and gas businesses may be driven out by elevated rents and inability to match oil and gas wages, while other local industries, such as tourism, may decline due to decreases in outdoor recreation visitors [107]. Economies can easily become over-adapted to extractive industries, making it harder to diversify [108], particularly if extractive industries have caused environmental harm which hinders amenity-based economic development.

2.3. Infrastructure impacts

Booms stress and increase demand for infrastructure. Communities that can afford to invest in infrastructure can benefit from boom-time expansion in businesses and entertainment options, hotels and apartments, and amenities like parks.

Booms involve dramatic upticks in heavy truck traffic to and from extraction sites [109–111]. Relative to conventional drilling, UOGD requires construction of significantly more new roads [112]; maintaining these roadways costs an estimated $13,000 to $23,000 per well [113]. Construction of new wastewater treatment centers [92] and on-site wastewater recycling infrastructure [114] may be required. Additional gas storage facilities and landfills may be needed to contain drilling products and by-products [10], and pipelines and compressor stations may be required for transport [115].

Many rural, low-volume roads and bridges are aging [116], were not designed to accommodate the intensity of use associated with UOGD, and deteriorate in consequence [15,92,110,111,116,117]. For example, drilling a single UOGD well in the Marcellus Shale region can require up to 2000 truck trips [118]; Traffic increases an area's population expands, increasing congestion, local air quality impairment, and traffic accidents and fatalities [119,120]. Localities may collect more fines and fees from traffic violations, but these monies are typically exceeded by increased infrastructure costs [92]. Residents living near UOGD sites complain about damages to transportation infrastructure from UOGD-linked trucking [110] and identify road damage, congestion, and transportation issues as substantially, adversely impacting quality of life [121]. Attitudes toward UOGD often influence resident perceptions; those who oppose UOGD are less likely to perceive infrastructure benefits and more likely to perceive infrastructure harms [122].

A boom's population influx increases demand on community infrastructure [123]; that is, features of the built environment that provide public services or amenities, such as water and sewer systems, hospitals and health clinics, schools, and recreational facilities [10,95,124–126]. Local governments may feel pressured to provide or expand such infrastructure, yet lack necessary personnel, expertise, or funds [4,10,127]. They may hesitate, alongside private investors with similar concerns, aware that the cyclical nature of booms and busts means that facilities may end up abandoned or underutilized while investors struggle to service debt [5,109,128]. Investors may be deterred by symptoms of social disintegration typical in booms, such as crime, or perceptions of government incapacity [125]. If private investment is not deterred, local officials may perceive it too politically risky to deny approvals for expanding housing or other infrastructure to meet short-term demand, even if they understand that such development will likely be unsustainable long-term [4].

2.4. Public health impacts

While UOGD does not appear to impact rural mortality rates positively or negatively [129], UOGD booms yield a variety of public health impacts associated with drilling itself and with interactions between oil and gas workers and the community [130]. Residents proximate to UOGD have reported symptoms such as rashes, fatigue, vomiting, dizziness, nose bleeds, and upper respiratory infections [131–133]. Prevalence of UOGD wells is also positively associated with increases in asthma exacerbations [134]. However, it is usually difficult to link adverse health outcomes specifically and directly to UOGD [135–137].

In general, living in a community with UOGD is associated with lower self-rated health [138]. Hospitalization rates for cardiology, dermatology, neurology, oncology, and urology are positively associated with well density [139]. Colorado residents living less than ½ mile from UOGD wells appear at greater risk for health problems than those living further away, largely due to the former's higher benzene exposure [140]. Health impacts diminish for families that move away from drilling or where drilling decreases over time but remain unchanged for families consistently living near high-intensity drilling [141].

Impacts appear more acute for vulnerable populations, including pregnant women, children, and those with underlying health conditions. In a study of more than 9000 patients with preexisting heart failure, those living near UOGD sites were more likely to be hospitalized than those living further away [142]. Pregnant women living near UOGD experience higher frequency of depression and anxiety prior to giving birth [143] and are more likely to have underweight infants [144–147], preterm birth [148]; their infants experience poorer health metrics [144,146] and higher rates of mortality [149]. Researchers speculate that these effects are linked to exposure to water and air pollution. Roughly 75 % of the more than 630 chemicals used in UOGD-related processes in the United States are associated with skin, eye, and respiratory irritation; 40 % with brain, immune, and cardiovascular problems; and 37 % with endocrine disruption [150].

The workforce that UOGD brings to communities is typically dominated by young, unmarried men with relatively low education [8,151]. Adverse public health impacts often result from increased interactions between these workers and the community, including increased hospitalizations for genital and urinary conditions [152]; increased incidence of chlamydia [153] and gonorrhea [154,155]; increased prostitution [154], heavy drinking [151], traffic accidents [23]; property crime [156 though see opposite results in 157] and violent crime [77,156,157], the latter potentially driven by upticks in aggravated and sexual assaults [157,158]; increased domestic violence and child protection cases [159]; and disproportionate in-migration of sex offenders [156].

These impacts can cause psychological stress [76,78,133]. A study of Pennsylvania residents found greater incidence of depression among those living near UOGD relative to similar populations living elsewhere [160]. Activities which could normally help ease depression can be hindered by UOGD: noise, light, and vibrations from active operations can disrupt sleep [117,118,161,162], and increased traffic can discourage residents from walking, hiking, or engaging in other outdoor physical activity [23,163].

2.5. Public service impacts

Public service impacts during a boom are direct, such as increased need for emergency response to well blowouts and spills, environmental monitoring, and leasing-related public records requests; and indirect, such as increased need for health services, schooling, and policing due to the influx of people and traffic [5,10]. UOGD often occurs in rural regions with small local governments that struggle to meet increased public service demands [92,164]. Local governments may be hindered by budget shortfalls, particularly early in a boom-bust cycle, since there can be a 3–8 year lag between peak local government expenditures related to UOGD and peak revenues [95]. Tax revenues may be insufficient for addressing local UOGD-related impacts [103,165], especially since industry profits often flow to out-of-state oil and gas companies rather than local outfits [5]. Local policy actors hold diverse perceptions of UOGD's impacts on public services; some communities report negative impacts, some neutral, and others positive [166].

Increases in traffic can cause public safety hazards [120]. Police may experience more calls for response to traffic accidents, drug overdoses, and incidents of domestic violence and crime [15,78,103]. For example, one North Dakota community heavily engaged in UOGD saw a 5 % increase in population and a 40 % increase in domestic violence calls [93]. In some areas of North Dakota, police service calls have quadrupled since 2008, including long-term residents calling in "suspicious" people they don't recognize [167]. Social isolation, lack of housing, an under-resourced justice system, and the hyper-masculine work culture of the UOGD industry drives the increase in domestic violence [159]. However, there is some evidence to suggest that crime rates are highly localized such that crime may increase in some counties, while still decreasing overall in the state (e.g., an 8 % reduction in overall crime in North Dakota during the boom); and that increases in crime rates may not be attributable to UOGD even if they correspond with the onset of the boom [168,169].

The boom's population influx increases demand for health care professionals, clinics, and hospital beds, often in areas already underserved by health providers [15,78,103]. Although workers who come to booming areas to work on oil and gas rigs are likely to be young, unmarried men [8], the expanding service sector is likely to be staffed by people with families whose children need schooling. Increased intimate partner violence may exacerbate housing precarity and increase the unhoused [170]. Facilities that support vulnerable populations, including homeless shelters and transition housing, may rapidly fill [171]. Social service workers in North Dakota report that the UOGD boom there led to significant increases in child protection and foster care cases [93].

2.6. Housing impacts

UOGD booms tend to decrease affordable housing and impact property values [165,172]. Increases in population spur demand, pushing up rents and home prices and making affordable housing scarce, particularly in rural, housing-limited areas [10,99,125,165,173]. Homelessness, overcrowded housing, housing shortages, and forced relocation can result, disproportionately affecting marginalized groups [10,174,175]. Housing shortages sometimes result in oil and gas workers living in temporary camps or hotels and motels [174]. Lack of affordable housing can have cascading effects, posing a challenge for attracting workers across a range of sectors [125].

There is mixed evidence on how UOGD impacts property values. Some research suggests proximity to UOGD devalues real estate, like an analysis finding an average drop in home values of 9 % in U.S. counties experiencing UOGD between 2000 and 2010 [6]. In Colorado, every extra oil and gas worker caused a $65 decrease in home prices [176] and properties lacking mineral rights and within 1 mile of UOGD experienced a 35 % drop in property values [177]. In the Dallas-Fort Worth area, homes within 3500 ft of UOGD experienced value declines of 1.5–3 % between 2005 and 2011 [178], and in Pennsylvania, well water-reliant households within 0.75 miles of a site permitted for UOGD averaged nearly 22 % decline in home values [179].

Property value declines may be linked to risk of groundwater contamination and difficulty obtaining property insurance [15]. Risk-wary mortgage lenders and insurance providers may avoid servicing areas proximate to UOGD [180]. Additionally, there is some indication that housing values decrease as the count of fracking wells within a half-mile of that house increases [181]. While these effects may be relatively short-lived and associated with early stages of well development, negative impacts associated with UOGD-linked traffic increases may be more persistent [179].

By contrast, an analysis in Oklahoma found that housing prices increased nearly 7 % on average in counties experiencing UOGD between 2000 and 2015 [182], while a study in northeastern Pennsylvania failed to find a relationship between UOGD proximity and property values [183]. In New York, properties overlaying shale but prevented from experiencing UOGD by that state's moratorium experienced a 23 % loss in property value relative to properties in neighboring Pennsylvania, where UOGD occurred; researchers argue this result points to meaningful economic value from UOGD [183]. A recent nuanced analysis found that while UOGD appears to increase property values by nearly 5 % when the economic impact of drilling alone is considered, when adverse health effects linked to UOGD are economically valued, the net impact of UOGD on housing prices is a loss of roughly 6–22 % in value [184].

Low-income individuals are disproportionately impacted when financing dries up for existing homes or developers are no longer incentivized to build in an area [185].

2.7. Social capital impacts

Booms often bring a sense of loss of community, community disintegration, social disruption and social disaffection [123,186]. Social impacts vary across regions based on the stage and intensity of the boom [187], the extent of the community's economic dependence on oil and gas, and contentiousness around UOGD [76,173,188]. Social impacts are driven by rapid economic growth and population influxes disturbing existing social networks, and increases in crime, traffic, gender-based violence, and drug use [78,103].

Residents are often concerned about newcomers stressing public services and community infrastructure, not understanding or valuing local culture, and not being invested in community's wellbeing [78,103]. Newcomers may experience hostility or resentment from longtime residents [78]. Researchers observe that, as newcomers engage with longtime residents, measurable decreases in community trust result, expressed by increased incidence of safety measures (e.g., locking doors) and decreased overtures of friendship (e.g., shaking hands) [189]. Moreover, researchers find a significant decrease in volunteerism, even among longtime residents, because of greater in-migration and social capital erosion [189]. In some places, residents felt that their identities were threatened by the influx of people, who were noticeably different from the more homogenous long-term community [190].

Residents who sought rural areas for aesthetics and peaceful quality of life, such as retirees, may leave as the community becomes more industrialized and experiences more pollution [76,95,191]. For those who remain, changes in the landscape and culture can prompt stress, anxiety, anger, loss of sense of place, and loss of trust in government and industry [76,78,133,162,192]. An analysis in the Dallas-Fort Worth region found that nearby UOGD is significantly associated with adverse mental health impacts and, for women, reduced life satisfaction [193]; a study in two Ohio counties affected by UOGD found that residents experienced multiple industry-linked psychological stressors [76].

UOGD can further fray social capital by increasing economic inequality between the "haves," largely holders of mineral rights, entrepreneurs, and business owners, and "have nots," including who do not own mineral rights or have low or fixed incomes but must now pay higher prices for housing, food, and necessities [77,103,194]. Yet even those who benefit from UOGD in may feel powerlessness, frustration, and a sense of manipulation or exploitation as they engage with the industry and experience its impacts [76,78].

The literature is not unanimous, however, in arguing that booms damage social cohesion. While work specific to UOGD is quite limited, oil and gas booms can offer avenues for community members to improve their social standing (via gaining wealth) and reduce reliance on food stamps, welfare, and social safety net programs whose users are sometimes stigmatized [188]. Some communities may rally together to overcome problems caused by both booms and busts, forging a new collective identity out of shared trauma [189]. And when residents interact with the newcomers, they do not experience feelings of social disintegration, expressing that they feel safe and supported in their communities [195].

3. Bust-time community impacts

We now turn to a synthesis of impacts from UOGD activity during busts. Overall, we found a dearth of literature on bust-time impacts in the United States, particularly on the topics of infrastructure and public services.

3.1. Environmental impacts

Research on UOGD environmental impacts during busts tends to focus on abandoned or idled oil and gas wells. During busts, operators frequently idle (leave unused) and/or abandon (idle for an extended, indefinite period, without proper sealing or closing) wells and other UOGD infrastructure [196]. There are an estimated 6,037,587 oil and gas wells in the United States; of these, approximately 1,159,689 are abandoned[4] [197]. In Pennsylvania alone, more than 6 % of the 8030 oil and gas wells drilled in Marcellus Shale between 2005 and 2013 experienced integrity failures [45]. Poor well integrity, broken casings, aging, and/or other infrastructure failures can leak liquids, gases, and hydrocarbon-rich fluids into groundwater, surface waters, and nearby soils [38,47,55,198,199]. Abandoned well pads and access roads can also create additional long-term environmental impacts like habitat fragmentation [90].

[4] There is some discrepancy over the total numbers of wells. The values used here reflect scaling up from state and federal database records and aeromagnetic surveys.

3.2. Economic impacts

As the boom wanes and bust begins, local governments face financial hardship as revenues dissipate [92]. Infrastructure built or expanded during the boom creates long-term budgetary concerns, as facilities require maintenance whether or not they are consistently used [95]. Communities see rising unemployment [124], upticks in poverty, losses in per capita income, and increases in welfare receipt [8,96,124]. If local businesses raised wages to compete with the oil and gas industry for workers, these businesses may now have to cut worker pay or staff [200]. In some cases, oil and gas industry employees find themselves working in minimum-wage jobs in other sectors while they await the industry's return [200]. Layoffs increase local unemployment. Out-migration can be significant [4,8], reducing the tax base and local expenditures on goods and services.

In the United States, many Marcellus and Utica shale-overlaying communities lost population and jobs between the onset of the region's UOGD boom in 2008 and the decline by 2019 [201]. In turn, out-migration may cause investors to avoid the region because of fears about lack of product demand and/or labor. In the agricultural sector, farmers reported having to abandon their farm practices even after production ceased and reclamation was completed because the land was no longer suitable for farming; the loss of their farms increased their dependence on oil and gas revenue, which exacerbated their financial plight after the bust [202]. However, not all UOGD busts are negatively viewed by communities, with some residents expressing "relief" when the scale of development decreases [203].

3.3. Infrastructure impacts

Communities are sometimes able to convert new or expanded infrastructure into multipurpose facilities that support ongoing use through UOGD bust-times. Localities may be able to sell off or loan out equipment that is no longer in use. However, some infrastructure may not be designed or suited for flexibility or may not be in demand elsewhere. Decommissioned, vacant, or otherwise unused infrastructure may saddle localities with debt and ongoing maintenance needs [10,109].

3.4. Public health impacts

While the literature on public health dynamics in busts is scant, scholarship suggests that addiction and gender-based violence can persist or increase during these downturns [193]. Residents may turn to drugs and alcohol to cope with economic hardship, while unhealthy stress and family disruption can result when men previously earning income outside the home remain in the home while out of work. Rates of anxiety, depression, and mental health problems can increase, driven by job loss and economic insecurity, as well as the sense of social disintegration and disruption [78]. During a bust's tight fiscal conditions, governments may cut or restrict services that could otherwise help residents cope with these dynamics [164].

3.5. Public service impacts

During a bust, some public services may experience less demand, and local governments may no longer need, nor be able to financially justify or support, staff hired to service boom-related needs. However, demand for some public services, such as emergency response to contamination from aging or damaged wells, may actually increase during a bust. In these cases, existing public funds and staffing may be insufficient. Additional long-term needs such as ongoing environmental monitoring which is key to identifying and mitigating post-drilling hazards [204] may be impossible in budget-constrained communities. This has the potential to exacerbate public service impacts during UOGD bust-times.

3.6. Housing impacts

Bust-times also drive decreases in housing demand, particularly if the community failed to establish more sustainable, longer-term sources of income [180]. Those who were previously employed in the industry now find themselves suddenly without company-provided housing, facing exorbitant rents, and without a steady source of income; and many company-provided lodgings are left abandoned [123]. While systematic research on the housing price impacts of UOGD busts are minimal, there is research that suggests a connection between oil prices and housing market fluctuations, such that housing booms are shorter during periods of high oil prices and housing busts are longer during periods of low oil prices [205].

3.7. Social capital impacts

In tandem with declined housing demand, job losses occurring during busts can cause mental health issues like distress and depression. Contracting of municipal revenues and public services can reduce residents' access to coping resources. Although workers without college degrees can often secure good-paying jobs locally during a boom, and thus may not pursue higher education, they may find their lack of a degree an obstacle to employment during busts, potentially increasing poverty [95]. A study of Montana, West Virginia, and North Dakota, for example, shows that shale energy booms are linked with lower levels of education attainment [206]. The boom-time erosion of social norms and community culture may continue during a bust [78].

4. Discussion

Booms and busts are dynamic processes often following a relatively well-established life course (see for example [18,19]). The boomtown life course literature shows long-enduring impacts common in energy development, particularly with regard to social integration. As our review demonstrates, these impacts affect many sectors, although there are some commonalities and consistency across diverse communities.

Based on our research, there are several opportunities for government intervention and engagement in UOGD boom-bust cycles. To begin with, there is a high degree of consensus on the environmental impacts communities experience during booms. Local governments should pay greater attention to minimizing the risks of wastewater contamination and noise, odor, and light pollution. Given that local governments have jurisdiction over permitting processes for UOGD [196], they have considerable leverage in requesting accommodations such as sound barriers, lights-off hours, and specific (i.e., closed) wastewater disposal systems. In addition, there is widespread agreement in the literature that infrastructure is strained, and public services are stretched thin during UOGD booms. Local governments can enter into MOUs (memoranda of understanding) with UOGD companies to require compensation for infrastructure upkeep and improvements and can assess permitting fees to cover the costs of enhanced public services.

Beyond the environment, infrastructure, and public services, there are few areas where there is a clear path for government intervention. Many public health studies show correlations between UOGD prevalence and adverse health indicators, but ascribing causality to UOGD is difficult. Though there is little local governments can do to prove or prevent health consequences, they could require full disclosure of the chemicals utilized in the process to enhance transparency and accountability in the industry. With more robust data, scholars and medical practitioners can better assess the degree to which the inputs into the UOGD process may be causing the reported health effects.

Similarly, the research fairly consistently demonstrates negative impacts to social capital and social cohesion during UOGD booms, but the nature of the problem makes it difficult to pinpoint a role for government. Paradoxically, because scholars seem to disagree most on economic and housing impacts, it is particularly challenging to identify government intervention points. Several studies find UOGD booms produce significant positive economic impacts overall, while a growing contingent find that the negative economic consequences of the bust outweigh the positive impacts of the boom. Similarly, studies present mixed findings on whether housing prices increase or decrease because of UOGD.

Local governments should focus their efforts on proactively addressing potential boom-time impacts, as those loom large in the literature. However, there are a few areas during UOGD busts in which government has a clear role to play. First, the literature is quite unanimous on the potential ramifications of abandoned and idled wells. Governments should, therefore, develop rules about the length of time wells may sit idle or abandoned before being properly plugged and sealed, and the area reclaimed. Further, local governments should seek expert consultation on formulating long-term plans including financial management strategies to minimize the economic impacts of the bust, including decreased need for public services, infrastructure, and housing. For a more extensive discussion of how local governments can respond to UOGD booms and busts, see Arnold et al. 2022 [215].

5. Conclusions & future directions

Research on community impacts of UOGD emphasizes boom-time impacts, particularly to the environment and public health, while there is relatively less attention to bust-time impacts and other social impacts like housing and social capital. Booms change local environments, communities, and economies and often lead to government public infrastructure investments. These fundamental changes continue to impact communities beyond initial boom-times, yet there is a persistent dearth of research on UOGD impacts during busts, and we have little understanding of these long-term dynamics in the United States.

Moving forward, scholars should continue to explore the community impacts of busts, particularly on underrepresented topics like public services and social capital, via long-term and comparative studies. One pathway may be to follow the boom-bust life approach of Ruddell and Ray [18]. There are many case studies of the social dimensions of community boom impacts, and case-based studies of how local governments respond with new regulatory, incentive-based, or public finance measures. However, there is a lack of comparative research, research on bust dynamics, and longitudinal studies that examine community dynamics throughout booms and busts. Our work in this vein is instrumental because we need to know more about how to effectively address and mitigate impacts to UOGD-affected communities, many of which are already vulnerable and marginalized.

Scholars should also pay attention to geographic variability, as recent work suggests that social impacts of UOGD are determined by the interrelationship between localized contextual variables such as geology, technology, and economics [21]. This should include looking locally across municipalities as well as cross-nationally at boom-bust cycles in other governance regimes outside the United States. Though the contexts vary along several dimensions, there is evidence to suggest that similar patterns are at play in international contexts, particularly in economically parallel countries like Canada [207,208], Australia [209,210], and the UK [211,212]. A larger-scale, international study could thus yield additional insights into coping with booms and busts in the US.

Furthermore, future studies should utilize a broad array of literature search techniques, such as alternative search engines or citation tracing to capture additional relevant scholarship. Though our search was methodical, it may be limited by the search engines or terms we selected; it is one of several approaches to literature searching that may be useful in this research. Because of this limitation, it is possible, that we missed relevant articles that did not appear in our searches for one reason or another.

Finally, we chose to use a qualitative synthesis approach to examine the impacts of boom-bust cycles to elucidate findings in the literature, as previous scholars have done (see for example [213]). Someone interested in broad thematic changes in scholarship may consider a more quantitative bibliometric review or a review from a more statistical vantage point (see, for example: [214]). This would allow scholars to quantify research trends (i.e., what is being published, where it is being published) over time.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

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