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The role of municipal ownership for urban net-zero path creation

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Particularly within recent years, the rising number of city actors worldwide declaring climate emergencies and pledging commitments to carbon neutrality has sparked a spatial turn in broader sustainable transition thinking, noting the importance of the local level for governing sustainable transitions. Using a Geographical Political Economy approach, this paper critically engages with path creation theory and sustainable transitions literature to explore the potential of urban net-zero carbon transitions in a multi-scalar governance framework. The main argument is that municipal ownership across sectors has a fundamental role in sustainable transitions at the city level. This paper makes a distinct conceptual contribution to sustainable transitions literature by drawing on path creation theory to illustrate how municipal ownership is a central tenet of path creation by bringing together local actors and enabling political capacity and agency to control and strategize integrated sustainable urban pathways. Using the transport and energy sectors in Nottingham in the UK, it applies the Path Creation Framework in an urban setting to illustrate that municipal ownership stimulates a positive path creation through three main arguments. First, municipal ownership enables a positive embeddedness and historical legacy in the provision of sustainable urban energy and transport services; second, it facilitates the establishment of skills and expertise that positively reinforces urban political capacity for the pursuit of urban sustainability; and third, it stimulates the creation of innovative urban projects for sustainable and equitable pathways.

KEYWORDS

path creation, municipal ownership, sustainable urban transitions, political capacity, municipal agency, local governance, place-based

1 Introduction

Within recent years, cities worldwide have been declaring climate emergencies beyond their respective national government commitments, and in doing so, are collectively shifting toward governance of sustainability and net-zero Carbon (NZC) transitions. In the UK alone, over 75% of local authorities have now declared climate emergencies; yet, local authorities are taking very different pathways amidst limitations such as complex policy landscapes, fragmented and short-lived national funding programmes, and insufficient financial and knowledge capacity (Webb et al., 2017; Gudde et al., 2021).

Despite these challenges, these purposive declarations have reignited multi-scalar, place-based and spatial considerations of governance and transition processes, emphasizing the urban (also referred to as place-based and local) as an important scale at which transitions processes are shaped, constrained and contested (e.g., Bridge et al., 2013). The transition to a decarbonised and equitable society is not simply confined to socio-technological changes, but highlights the complex political and institutional nature that requires a governance approach involving a myriad of state and non-state

actors across multiple levels, spaces and places (Bulkeley and Betsill, 2010; Ehnert et al., 2018). The emphasis on a multi-scalar, place-based and spatial engagement places a renewed significance on actor agency and capacity on the ability to reconfigure and shape pathways toward NZC trajectories, particularly in urban areas which are conceptualized as places comprised of changing relations between actors, materials, cultures, structures and histories (Binz et al., 2020; Eadson and Van Veelen, 2023).

The various forms of local and shared ownership models have become increasingly acknowledged as fundamental for delivering the multi-level governance of inclusive NZC transformation. The benefits of shared and local ownership models include the ability to fulfill gaps in resources, knowledge and expertise, opportunities for sustainable financial returns, community acceptance, greater energy democracy and decision making, and wider forms of the inclusive transition (Bull and Eadson, 2023). Research has highlighted the notable increase in these initiatives, ranging from community ownership of low carbon energy assets (e.g., Markatoni, 2016; Bush et al., 2017), joint-ventures and public-private partnerships such as Energy Service Companies (e.g., Hall et al., 2016; Nolden and Sorrell, 2016; Thompson et al., 2020), in addition to "re-municipalisation" of education, water, health, social care and energy, in pursuits to reclaim greater control for the common good (e.g., Kishimoto et al., 2020; Thompson et al., 2020; Paul and Cumbers, 2021). Local actors and their ownership of assets can therefore be considered as important intermediaries in sustainable urban transitions, working as key catalysts by facilitating activities, skills and resources to create momentum for change (Hodson et al., 2013; Bush et al., 2017; Kivimaa et al., 2019).

While there has been a distinct avenue of research investigating the role of localities in implementing sustainable energy transitions; the application of path creation theory to examine processes of urban transitions are however somewhat underdeveloped (e.g., Hassink et al., 2019; Mackinnon et al., 2019). This paper brings together urban sustainable transitions literature and path creation theory to examine how contemporary urban sustainable trajectories are shaped, and in doing so, places a renewed emphasis on municipal agency and ownership for NZC transitions. The analysis combines conceptual theories on urban agency and municipal ownership and sustainable path creation to answer the following key research question: *What is the role of municipal ownership in path creation of sustainable urban transitions?*

Through a Geographical Political Economy approach, this paper makes a distinct conceptual contribution to sustainable transitions literature by engaging path creation theory to explore the potential of place-based net-zero carbon transitions in a multi-scalar governance framework. In doing so, this research demonstrates that municipal ownership brings together local actors and enables political capacity and agency to control and strategize integrated sustainable urban pathways, thereby having a fundamental role in fostering place-based sustainable pathways. Using the transport and energy sectors in Nottingham in the UK, it applies the Path Creation Framework by Mackinnon et al. (2019) in an urban setting to illustrate that municipal ownership is a central tenet to path creation debate and stimulates a positive path creation through three main arguments. First, municipal ownership enables a positive embeddedness and historical legacy in the provision of sustainable urban energy and transport services; second, it facilitates the establishment of skills and expertise that positively reinforces urban political capacity for the pursuit of urban sustainability; and third, it stimulates the creation of innovative urban projects for sustainable and equitable pathways.

The paper is structured as follows: the next section discusses multi-level governance of sustainable urban transitions, and municipal agency, political capacity and ownership for shaping sustainable trajectories. Section 3 introduces the conceptual framing of path creation theory for urban sustainable transitions and introduces Mackinnon et al. (2019) Path Creation Framework to discuss how these framings can aid understanding of sustainable urban transitions across sectors. Section 4 provides an overview of the methodology, as well as introducing the empirical case study of Nottingham in the UK. Section 5 applies the Path Creation Framework to these research findings, before presenting a discussion and suggesting avenues for future research in Section 6. The last section concludes.

2 Literature review

2.1 Multi-level governance for sustainable urban transitions

Existing research has emphasized that climate change governance not only comprises state actors who have a key role in enabling NZC transitions, but equally involves cooperation with non-state actors, such as civil society, private enterprise and non-governmental organizations; all of whom have a powerful and competing interest at stake (e.g., Di Gregorio et al., 2019). The collaboration of these actors across international, national and local levels is commonly referred to as "multi-level" or "multi-scalar governance" and governments worldwide are becoming increasingly aware of the need for multi-level governance for achieving decarbonization ambitions.

There have been a number of theoretical frameworks which seek to further understandings of sustainability transitions. For example, the "Multi-Level Perspective" (Geels, 2005) offers a socio-technical approach to emphasize energy systems as complex arrangements which are comprised of, and co-produced by social and technical elements, and which occur through three different levels: technological niche (micro-level); socio-technical regime (meso-level) and the socio-technical landscape (macro-level). Whilst it highlights the multiple and varied agency of actors at niche and regime levels, and the ability of local institutions to progress transitions (e.g., Fudge et al., 2016), it has been critiqued as having a lack of attention to the role of agency with regard to different actors or social groups (Whitmarsh, 2012; Fischer and Newig, 2016). Particularly, the development of the "Multi-actor Perspective" (Avelino and Wittmayer, 2015) seeks to address this gap and incorporates the different jurisdictional boundaries, the multiple levels of institutions and plurality of actors at play in sustainable transitions. In doing so, it employs a socio-political approach, accounting for the differentiated agency and roles of a fuller range of actors beyond that of incumbent actors that often receive most of the attention (such as civic, third sector and private sector).

Yet, whilst there are merits in both these frameworks, they have been received criticism. For example, the Multi-actor Perspective does not address the processes of sustainability transitions, and the oversight of attention to space, place and scale in frameworks such as the Multi-Level Perspective have been noted as "[risking] theoretical lock-in in the long term" (e.g., Binz et al., 2020, p. 1). As such, there has been need for greater sensitivity and attention to scales, places, context-specific factors, politics and spatialities shaping transitions (Essletzbichler, 2012; Huang et al., 2019; Binz et al., 2020; Bridge and Gailing, 2020).

There have been a number of studies which already take some of these into consideration and help to theorize place-based urban transitions. For example, Huang et al. (2019) develop and empirically apply the urban contexts to the Dimensions of Urban Energy Transitions Framework, taking into consideration the socio-spatial and political interactions that shape urban energy transitions. In addition, Monstadt and Wolff (2015) examine the transformative capacity of environmental policies for urban energy transitions through the case study of the Los Angeles Department of Water and Power, and in doing so, put focus on place-specific politics and contexts.

The path creation conceptual framework is a useful addition to this evolving literature by placing a renewed focus on the role of local actors, their agency, political capacity and ownership across scales for governing sustainable transitions, highlighting in particular the different processes constraining and progressing transitions (as further discussed in Section 3).

2.2 Local agency, capacity and ownership in sustainable urban trajectories

Municipal state and non-state actors (e.g., third sector, private sector, and civil society) have a fundamental "agency" (broadly defined as one's ability to think, act, manage and intervene in a given process and situation) in mitigating sustainable transitions through their individual and collective capacity (Gibbs and Krueger, 2005). This is demonstrated by the recent and growing number of cities across the world declaring climate emergencies and subsequently adopting new climate policies and mandating for further political action. In many cases, cities are actively going against the status quo of their national governments by declaring a climate crisis and moving toward net-zero agendas, particularly during challenges of austerity and undertaking new forms of entrepreneurialism (Featherstone et al., 2012; Gibbs and Lintz, 2016; Thompson et al., 2020).

The agency and political capacity of municipal actors has been the topic of much discussion within urban sustainable transitions literature. Whilst local governments are considered to have a key role to play in developing transitions, for example through their role as important intermediaries (e.g., Hodson et al., 2013; Webb et al., 2016), there are recognized limitations in local actors' ability to enact change. For example, Kuzemko and Britton (2020, p. 2) define capacity as "the ability to take political decisions in pursuit of agreed public policy goals." In doing so, they illustrate how local government actors have various forms of capacity in terms of: responsibility, political authority, finance, personnel, knowledge, and energy materiality (i.e., proximity to energy resources, local energy infrastructures). Exploring actors' capacity is hence important for understanding the possibilities, tensions and limitations of local actors for implementing sustainable urban transitions, and the highly politicized nature of steering pathways. Here, ownership notably spans across these capacities, and particularly for local political authority, enables "more visible important links between policy decisions aimed at local benefit" (p. 8). This research connects municipal ownership with capacity more explicitly, to demonstrate its ability to foster sustainable trajectories.

With the acknowledgment of local government as important intermediaries in NZC transitions, various forms of ownerships have emerged to overcome the aforementioned capacity limitations encountered by local government actors. For instance, public-private partnerships (such as Bristol City Leap) and Energy Service Companies (ESCos) are joint ventures which often involve local authorities in energy services in various forms of ownership. As novel and innovative approaches, these signify local government involvement and ownership in city-wide decarbonization (e.g., Hannon and Bolton, 2015; Nolden et al., 2023). In contrast to the status quo of private oligopoly energy companies, these shared and local forms of ownership have been heralded as being more appropriate for enabling socially-just NZC transitions, with benefits including: profits re-invested into local public services; greater energy democracy and local decision-making; greater community acceptance; and fulfilled gaps in resources, knowledge and expertise. Notably, the municipal ownership of common goods such as water and energy has encountered a resurgence in recent years across the globe with new initiatives emerging in cities such as Barcelona and Grenoble commonly known as "remunicipalisation" (Cumbers, 2012; Cumbers and Paul, 2020). For example, this process has ranged from municipalities "buying back" the existing electricity network (e.g., over 305 cases in German energy sector since 1990), to the building of new low carbon systems by communities (e.g., wind farms and solar farms in western Europe) (Cumbers and Paul, 2020). These findings demonstrate the collective desire for greater public control for the common good in attempts to break away from marketised imperatives of neoliberalism, which often lead to poor experiences of service provision under privatization (Cumbers and Paul, 2020). Yet, there are more critical re-interpretations of re-municipalisation as a response to privatization that need to be acknowledged, for instance, Voorn et al. (2020) assert that municipally-owned corporations continue to operate in a business-like manner and are undertaken due to cost-savings or similar pragmatic reasons, rather than ideological reasons. These may operate at arm's length, therefore do not operate as a return to full public ownership.

Nevertheless, this active agency of municipal and local actors across places in various forms of municipal and shared ownership speaks to the wider desire of cities to actively steer urban trajectories. In doing so, this changing ownership—past or present—enables greater municipal control for the creation (and continuous shaping) of more sustainable and inclusive urban pathways.

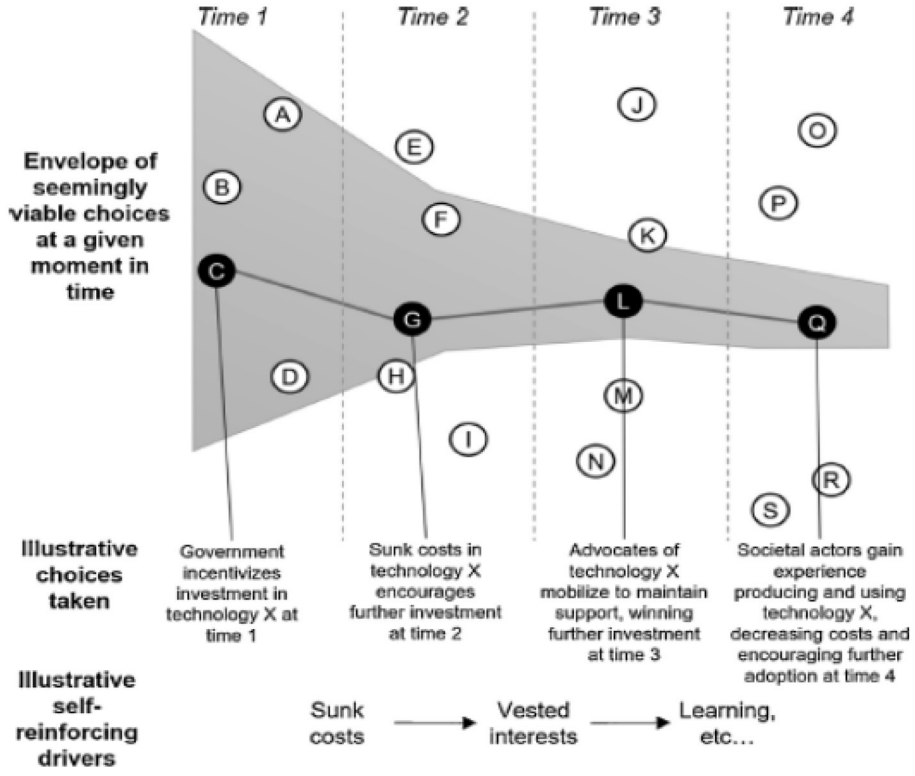

FIGURE 1
Schematic representation of a path-dependent process. Source: Rosenbloom et al. (2019, p. 171).

3 Conceptual framework

3.1 Path creation theory

The notion of path creation is particularly influential for understanding processes of NZC urban transitions; yet, it is a concept that has been under-theorized in comparison to the complementary notions of lock-in and path-dependency and there is no commonly accepted definition of path creation (e.g., Dawley et al., 2015; Hassink et al., 2019; Mackinnon et al., 2019; Eadson and Van Veelen, 2023).

Briefly, lock-in and path-dependency are useful concepts to the process of carbon-intensive, fossil fuel-based technological systems persisting over time (Unruh, 2002). As a result, carbon-intensive industries become path-dependent from having significant "sunk" costs from earlier investments, which leads to lower-carbon alternatives systemically becoming excluded and locked-out (Figure 1) (Unruh, 2002; Erickson et al., 2015). Importantly, there are different types of lock-in which exist, for example political lock-in, technological lock-in and institutional lock-in (Foxon, 2002; Hassink, 2005), yet it is important to emphasize here the high degree of place-dependence of lock-in (and the various form it comprises), and the problem of path dependence lies in "the extraordinary rigidity of the stabilized solution" (Makinen et al., 2015, p. 487). This point is important here for sustainable urban transition understanding, as it reinforces the strong relationship of place and urban materiality and its effects on actor agency, which can in turn affect wider governance and the overall pattern of sustainable trajectories.

Conversely, the concept of path creation follows a different ontology to lock-in and path-dependency (Makinen et al., 2015) and can be considered here as a route for *overcoming* lock-in and blockages of incumbent actors and technologies, intentionally deviating from existing artifacts and moving toward new alternative paths and facilitate trajectories to low carbon energy systems (e.g., Simmie, 2012; Fischer and Newig, 2016). The concept focuses on the notion of agency behind path formation, rather than systems themselves (Garud and Karnoe, 2001 in Makinen et al., 2015). In turn, this provides a renewed emphasis on the forms of actor agency and governance at the local level. In other words, new paths emerge from the strategic agency in heterogenous groups that jointly act upon locked-in structures and mobilize resources to create new pathways (Binz et al., 2020).

Stemming from evolutionary economic geography, scholars have applied the concept of path creation in different ways, with current research predominantly focusing on regional development approaches and understandings of path creation as the "rise of new industries in regions" (Hassink et al., 2019, p. 1636). Whilst most research has concentrated on regional scales and thus exclude urban scales, there are notable findings for understanding local applications. For example, in their analysis of biomass adoption in Europe, Panori et al. (2022) note the importance of public involvement and collaboration of local actors for path creation, and the need to understand wider contexts of energy transitions. This builds on suggestions to extend analytical focus beyond actors such

as firms and entrepreneurs, and toward multiple actors, including policy actors and the state (Hassink et al., 2019), which is useful for furthering understanding of urban agency and conceptualizations taken forth in this paper. In addition, Eadson and Van Veelen (2023) combine path development literature with just transition concepts to develop a novel conceptualization of "green and just path development." In doing so, they contribute to the convergence of path creation in sustainable transitions understanding, yet suitably note the research question whether ownership structures may lead to different modes of path development, which this research aims to advance.

3.2 Geographical political economy approach to path creation theory: path creation framework

Advancing a Geographical Political Economy approach, Mackinnon et al. (2019) make a distinct contribution to transition understanding by developing a multi-dimensional and systematic theoretical framework of regional path creation. A Geographical Political Economy approach is particularly well-suited to sustainable transitions by emphasizing the multi-scalar character of space and place, in addition to the legacies of history and agency of actors in shaping sustainable pathways (Chlebna and Simmie, 2018; Bridge and Gailing, 2020; Eadson and Van Veelen, 2023). Adopting this lens, Mackinnon et al. (2019) assert that the process of path creation is dependent on five key elements: (1) institutional elements; (2) key economic, social and institutional actors; (3) market construction; (4) regional and extra regional assets; and (5) mechanisms of path creation (Table 1 and Figure 2).

In this framework, the authors argue that there are three main forms to foster regional path creation: firstly, whereby it operates *in the context of* institutional environments and key actors to identify and harness regional assets; secondly, whereby path creation is *dependent on* actors coupling assets to generate path creation through *mechanisms* such as diversification, path creation and transplantation; and thirdly, through matching assets and mechanism to propel the growth of path creation. This framework builds on existing research (e.g., Binz et al., 2020) who identify four core elements—knowledge creation, investment mobilization, market formation and technology legitimation to describe how resources get mobilized, aligned and anchored in path creation.

Through having understandings from transition studies, this theoretical framework therefore is particularly fruitful for this research and its application to examining NZC transitions. Primarily, it allows the systematic analysis of the key dimensions of path creation and their inter-relations in an empirical urban setting, allowing for further understanding of sustainable urban energy transitions in practice. In applying this framework, there are three main important conceptual contributions of this paper. First, by applying Mackinnon et al.'s (2019) Path Creation Framework using a contemporary urban context, rather than regional (as per its primary conception), this paper demonstrates the applicability of the framework for understanding multi-level governance of sustainability transitions. Maintaining a Geographical Political Economy approach, it makes an empirical contribution to sustainable transitions thinking by using path creation theory beyond its most common use which is in evolutionary economic geography for explaining the emergence of new regional industries and industrial path development (Eadson and Van Veelen, 2023). Second, this framework allows the application of empirical data to include that from two sectors, that is, energy (supply and demand) and transport, to develop an integrated approach across sectors and the city. This is important for developing understanding of urban-led transitions, since low carbon urban transitions are not only constrained to one sector, but include the integration of multiple sectors e.g., transport, waste and water, thereby avoiding a siloed approach. Finally, this research adopts a renewed emphasis of local actor and municipal agency, political capacity and ownership (which to date have been under-represented in the literature) and integrates these concepts successfully through the empirical data. Whilst this application is used in a UK context, this has potential for understanding wider sustainable urban trajectories globally.

TABLE 1 Five key elements of path creation, adapted from Mackinnon et al. (2019).

Elements	Definition
Institutional elements	Refers to the multi-scalar interplay of local, regional and national rules and norms that inform or constrain the behavior and strategies of governing actors.
Key actors	Refers to those with agency to act or intervene, often challenging existing rules and norms in attempts to institutionalize alternative rules and practices, e.g., through gradual transformation or place-based leadership to enroll other interests and actors into collective visions and actions.
Market construction	Referred to here in a capitalist economy as having a key role in creation and reproducing a regional path through generation economic value through operation, and hence creating new momentum and direction.
Regional and extra-regional assets	Encompass a broad range which may include natural assets, infrastructure and material assets, industrial assets, and human assets, which are modified and reconstructed through deliberate and purposeful action of actors to progress a certain trajectory.
Mechanisms of path creation	Refers to the ability to generate and foster self-reinforcing growth, e.g., through external economies and increasing returns, to gain momentum and further reproduction to shape future outcomes.

4 Methodology

4.1 Nottingham case study

This paper builds upon previous research conducted in 2017–2019, which uses Nottingham as a case study to examine low carbon and just urban transitions in practice. Whilst there is no one preferred method for researching sustainability, case studies are the most frequently adopted research strategy for urban researchers

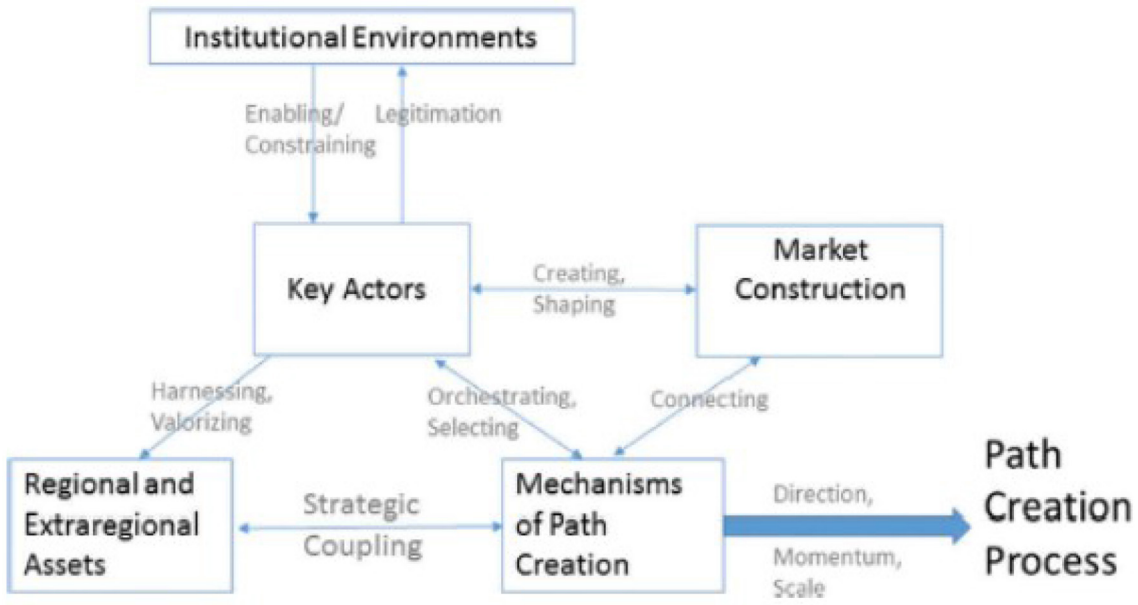

FIGURE 2
Path creation framework. Source: Mackinnon et al. (2019, p. 9).

(Zolfagharian et al., 2019), allowing the ability to explore and investigate complex real-life phenomenon through using detailed contextual analysis of events or conditions and their relationships.

Nottingham is a mid-sized city located in the East Midlands of England, and spans two local authorities, Nottingham City Council (with a population of ~300,000 inhabitants that comprise the urban conurbation) and Nottinghamshire County Council, which include the outer rural areas. Nottingham has made distinctive progress within recent years in the field of sustainable transitions, and a notable example of this is the city's ambitious climate change goals, with the most recent announcement in 2020 "to make the city the first carbon neutral city in the UK by 2028" (Nottingham City Council, 2020). Nottingham's intention complemented the integrated approach of this study, with the emergence of low carbon initiatives across transport and energy, which therefore allowed for a more holistic view of sustainable transitions at the urban scale in comparison to a focus on a single domain (Durrant et al., 2018). The city's unfortunate persistence and exacerbation of inequality was particularly important for researching justice dimensions in low carbon transitions. Nottingham was ranked 11th most deprived out of 317 districts in England in the 2019 Indices of Multiple Deprivation, an increase from 8th in 2015 (Nottingham Insight, 2019). In tandem with this, 30% of the city's Lower Super Output Areas (LSOAs) fall amongst the 10% most deprived in England. Nottingham has a higher than average rate of people with a limiting long-term disability or illness (Nottingham Insight, 2019). The latest ratings of fuel poverty in the city were at 14.6% in 2016/2017, which is higher in comparison to the rest of England which had an average of 10.2% in 2017 (UK Government, 2019). This case study is unique having received limited academic attention in terms of low carbon and equitable transitions, and the municipal ownership of energy and transport sector outlined in this paper further reinforces the valuable contribution of these findings and development of the path creation framework.

4.2 Data collection and analysis

This research focused on the social and political nature of sustainable and inclusive urban transitions, and therefore a qualitative mixed-methods design was the most suitable for obtaining in-depth opinions, views and perceptions from a range of sources.

The use of interviews was the main source of data collection and in total 35 semi-structured interviews were conducted with state and non-state actors across the sectors of energy, housing and transport (Supplementary Table 1). Interviewees were determined by their position in relation to the research project and was largely made up of sustainability advocates, or those working within the field of urban sustainable transitions. The employment position of interviewees varied significant to allow a range of positions and opinions to be collected, for example, from those working more directly with members of the public (such as fuel poverty officers), to those who had responsibility for initiatives (such as project officers), to those who were senior in strategy and development (for examples heads of department). The interviewees names and positions within each organization however have not listed to protect participant anonymity. Interviews were conducted face-to-face, and where this was not appropriate or possible, online and via telephone. The style of each interview was informal, in-depth and semi-structured based on open-ended questions around predominant themes which emerged from pre-read literature and research (Supplementary Table 2). This choice of structure allowed fluidity and flexibility of the conversation as opposed to structured

interviewing techniques. Each interview varied in content and design depending on the participants' role, background, function and knowledge, with interviews recorded and transcribed verbatim. The length of interviews generally lasted between 60 to 90 min in duration per interview.

The use of interviews as the primary data collection method was enhanced by desk-based documentary analysis, which consisted primarily of online documentary sources. Documents ranged by those produced formally by local and national governments and third sector organizations (such as policy and strategy), to more informal documents such as news articles, websites and blogs (Supplementary Table 3). Observational research and site-specific visits were another data collection method used during this time to provide a deeper analysis of social processes and helped to identify fluid, complex and shifting issues (Supplementary Table 4). Both these forms of data collection were important, however comprised a less substantive part of data collection.

The data collection was not conducted to test the Path Creation Framework *per se*, but was part of a broader evaluation project of city level governance for a low carbon and just transition. For analysis, data were collated and inputted into qualitative research computer software "NVivo" where it was subsequently coded to discover predominant and emerging themes (Supplementary Table 5). These findings were then applied deductively to the Path Creation Framework to reveal results of the case study, taking the energy sector and transport sector in turn. The results are therefore framed around the components of Path Creation Framework by Mackinnon et al. (2019). Here, the framework has been modified for the purposes of this research, which will be reflected upon in the discussion in Section 6 (Table 2 and Figure 3).

5 Results

5.1 Municipal assets of energy and transport infrastructure

The municipal ownership of energy and transport assets and infrastructure has had a particularly strong impact on historical, place-based legacies, resulting in a positive effect on path creation in Nottingham's progress to a NZC transition.

In terms of its energy sector, Nottingham is one of few cities in the UK which has a district heating system [excluding UK city examples such as Sheffield (Bull and Eadson, 2023) and Aberdeen (Webb, 2015)]. Nottingham's district heating system, established in 1962 by the National Coal Board was to provide heating and hot water to ~7,000 dwellings, civic buildings, colleges and shopping malls, and to supply steam for industrial loads (Lawson and Mason, 1974).

Instead of privatization from 1980s which witnessed the liberalization and restructuring of the majority of the UK's energy sector into private corporations, today's retention of the district heating system by the municipality has resulted in the system being wholly owned by Nottingham City Council under the arms-length management organization (ALMO) Energy Services Company (ESCo) Enviroenergy (Enviroenergy., 2023). According to one interviewee, the historical delivery of the district heating scheme in Nottingham has *"enabled the city to continuously build and expand upon this district heating system and make savings from sunk costs in existing infrastructure which was built almost 40 years ago"* (Interview with Nottingham City Council). Through this early urban engineering, Nottingham is considered as a pioneer of Energy from Waste, with the first incinerator being built in 1873 (Bull and Eadson, 2023). This historical legacy has enabled a pattern of positive self-reinforcement which in turn has aided political capacity to drive forward sustainable futures in the form of low carbon heat. The present 68 km district heating network is the UK's largest, supplying heat and hot water for 4,700 dwellings and over 100 commercial partners such as the Nottingham Arena and Nottingham Trent University (Vital Energi, 2023). The heat energy supplying these buildings is from the incineration of 160,000 tons of the city's municipal waste at the Eastcroft Incinerator (Enviroenergy., 2023)—a form of sustainable energy which replaced, and continues to replace, the need to burn fossil fuels for heating and hot water.

Maintaining municipal ownership of the district heating system through an ALMO has simultaneously allowed the city to build the city's Energy Directorate, which can also be regarded as human assets. Arguably, without the council's role in this Energy Services, the city council would not have acquired the current knowledge, skills and expertise needed to strengthen the path creation of sustainability (discussed in Sections 5.2, 5.5). As highlighted by one interviewee, this existence of Nottingham's ESCo has allowed for the development of learning and expertise in the field over three decades, both through Enviroenergy as a separate ALMO, but also directly within the Council's Energy Directorate, which has full in-house operation covering generation, distribution and network operations, metering, retail and billing (Interview with Robin Hood Energy). The past and present legacies of this can therefore be considered as sunken costs which reinforce path creation of district heating (discussed in Section 5.5).

Similar to Nottingham's energy sector, the city council went against the status quo to maintain municipal control of its transport network, and it is with this historical and place-based legacy that has provided positive benefits for the city's transition to a sustainable transport network. Unlike most UK cities, Nottingham City Council retained ownership of its bus network by establishing the ALMO Nottingham City Transport in 1986 and retained 100% equity of the company until 2000, after which Transdev acquired an effective 18% stake in the corporation (Transdev, 2020). Nottingham City Transport (NCT) is the largest commercial operator in Nottingham, with the private company Trent Barton being second to this. The ownership of this transport asset has been favorable for the city: *It helps that we own our own bus company, as there has always been that investment in public transport in the infrastructure—whether that's things like bus priority or the real-time system at bus stops which we have a really big system in comparison to most cities" (Interview with Nottingham City Council).*

In both cases, land ownership of the council has been equally important to Nottingham City Council in order to implement a low carbon transition in the energy and transport sector. In the case of transport, as stated by one interviewee: *"We were quite lucky that we had land available to install the infrastructure [. . .] if we had not had land available at our park and ride site, that would have been*

TABLE 2 Path Creation in Nottingham's energy and transport sector (adapted from Mackinnon et al., 2019).

Key elements (adapted from Mackinnon et al., 2019)	Nottingham's energy sector	Nottingham's transport sector
Municipal assets of energy and transport infrastructure	Infrastructural assets: Municipally owned District heating system, set up in 1960s Human assets: "Enviroenergy" (ALMO) and on-going Energy Services directorate comprising 40 members of staff Institutional assets: sunken cost and ownership of heat network, planning network	Infrastructural assets: Municipal ownership in bus network since 1980s, (presently has a 72% stake) Land ownership (development of park and ride); low carbon fleet Human assets Institutional assets: transport planning network and operational capacity over urban area
Key Municipal Actors	Innovative/institutional entrepreneurship: individual councilors and council staff, particularly bold leadership with strong political will as path advocates for sustainability [e.g., Robin Hood Energy (ESCo)]	Innovative/institutional entrepreneurship: Workplace Parking Levy Institutional embeddedness: long history of Labor party and ability to plan long-term
Local and National Institutional environments	Local authority structure: unitary structure within Nottingham City Council Institutional embeddedness: long history of Labor party and ability to plan long-term National context of fiscal austerity. Private energy companies, going against status quo	Local authority structure: unitary structure within Nottingham City Council Institutional embeddedness: long history of Labor party and ability to plan long-term National context of fiscal austerity. Deregulated bus networks operated by private companies (Great Britain)
Market formation and place-based finance	Attempts to use hypothecated funds to provide more equitable form of energy supply from municipal ESCo (e.g., tariffs for Nottingham citizens, voluntarily offering warm home discount, lean structure)	Place-based hypothecated funds (e.g., Workplace Parking Levy and tram extension), re-investment for low carbon bus fleet and EV charge-points Provision of affordable low carbon transport network through municipal stake in bus network
Mechanism of path creation	Development of skills, expertise and staff capacity to enable sustainable energy projects Self-reinforcing growth sustaining projects	Development of skills, expertise and staff capacity to enable sustainable transport schemes Self-reinforcing growth sustaining sustainable transport projects

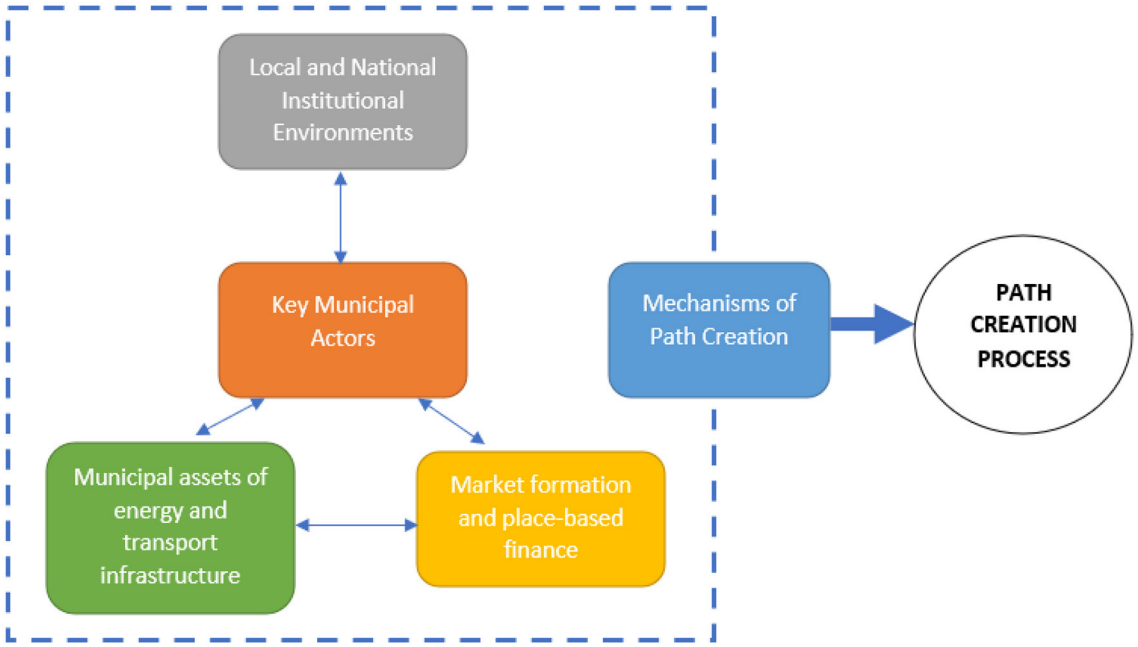

FIGURE 3
Illustrative diagram of path creation in Nottingham (adapted from Mackinnon et al., 2019).

quite a significant issue for us as a local authority as we would have had to go out and purchase land and that would have added to cost and all the issues around planning" (Interview with Nottingham City Council). This municipal ownership therefore has positive impacts on local institutional factors, such as planning consent, being within the council's control (as elaborated further in Section 5.3).

5.2 Key municipal actors

According to research findings, innovative and entrepreneurial projects are largely due to strong individuals within the council. Nottingham City Council has two pertinent examples of innovative and entrepreneurial projects within both its energy and transport sector.

Until the privatization of Robin Hood Energy in 2018 due to overwhelming debts, Robin Hood Energy was a municipally-owned ESCO established in 2013 by Nottingham City Council. Despite this scheme not surviving the energy market dominated by an oligopoly of the big six private energy utilities (Traill and Cumbers, 2022), the establishment of Robin Hood Energy was a deliberate attempt by the actors within the City Council to provide a domestic supplier of electricity and gas, whilst at the same time, tackle fuel poverty, which has been a persistent problem in Nottingham and the wider UK. The formulation of the ESCo was fueled by limited competition in the energy market in the East Midlands area, a poor representation of existing energy suppliers, a disengaged base of residents and a high number of Nottingham residents on prepayment meters—all of which Robin Hood Energy sought to address from its establishment (Interview with Robin Hood Energy).

Turning to the transport sector, to date Nottingham's Workplace Parking Levy (WPL) it is the first of its kind in the UK and Europe, having been introduced by Nottingham City Council in April 2012 and builds on the Transport Act 2000, a policy instrument introduced in England and Wales to permit the creation of local congestion charges. The motivations behind this initiative were premised on firstly, a commitment to tackle congestion traffic problems in the city, which accounted for approximately £160 million per year during the AM peak period of which 70% of the traffic was commuters (Hallam and Gibbons, 2017); and secondly, as part of a commitment to encourage economic growth in the city. At the time of creation, the scheme caused much contestation and was perceived by businesses, politicians and civil society alike to be unnecessary business taxation and would discourage business investment, stunt economic growth and have minimal impact on traffic congestion (Interview with Nottingham City Council; Dale, 2017). As such, there were no strong environmental drivers for the scheme; yet, the business model has provided a secure income to pay off public loans from the tram extension (discussed further in Section 5.4).

In both energy and transport cases, Robin Hood Energy and Workplace Parking Levy required people in power who were progressive, bold and had a long-term drive for environmental sustainability to drive these ideas and projects from conception to fruition. Particularly going against the grain in comparison to other UK cities, in these examples, these key municipal actors are considered to act as path advocates with a strong vision to set the course of a sustainable path. As highlighted, "*On the face of it [the schemes] are not an obvious vote winner, you've really got to be quite bold and ambitious to be prepared to do it… [the City Council] had people in power who have been very progressive about what they want for their city […] and perhaps being prepared to go that bit further" (Interview with Nottingham City Council).* In addition, another interviewee mentioned other conflicting factors for bold decision-making, such as financial and political risk aversion of UK councils which has been shaped by national austerity and affected local capacity and risk-taking: *"at the moment, councils are being squeezed and squeezed in terms of budget […[You've got to have a lot of confidence to do that, so I think that's why the model hasn't been adopted more widely" (Interview with Robin Hood Energy).*

5.3 Local institutional environments

Related to key actors, Nottingham's local institutional environments have generally had a beneficial impact on the city's path creation for NZC transitions; yet, the impact of national institutional environment is questionable.

Related to local institutional environments, across the urban conurbation, Nottingham is governed by two local authorities: Nottingham City Council and Nottinghamshire County Council. Nottingham City Council as a unitary authority since 1998 has responsibility for all local services, such as transport, housing and planning whereas Nottinghamshire County Council has responsibilities split between districts and boroughs. Due to these differences in responsibility (e.g., in housing), one interviewee argued that this has led to a different engagement between the councils, with councils which do not have statutory responsibility *"not being engaged in these areas, as this is not within their remit, political authority or responsibility"* (Interview with Nottinghamshire County Council). As such, the structure of the local authority grants the city council political autonomy over decision-making. In the case of Nottingham, decisions are predominantly made in-house within the one-tier City Council, and therefore minimize the requirement for external stakeholder decision-making which can also be hindered from differing political priorities and result in a lengthier process. Consequently, the different levels of responsibility have resulted in varying political authority which is impacting decision-making and political capacity to implement low carbon projects.

In addition, the long-term political stability and consistency at the City Council administration level has enabled a strong collective leadership and political will. Historically, the Labor party are ideologically socially democratic, which is commonly aligned with more environmentally and socially-conscious values. This is certainly the case in Nottingham, and the environmental and social consciousness is possibly more distinctive in Nottingham than other English Labor councils, as stated: *"Everything we do is through a lens of reducing deprivation and supporting the most vulnerable in society…"* (Interview with Nottingham City Council). Notably, Nottingham City Council has had sustainability at the forefront of the city's political agenda more so than other UK cities, and sustainability has been embedded within the function of the City Council (Interview with Nottinghamshire County Council). For example, the Nottingham Declaration was a voluntary pledge signed in October 2000 by 326 local government bodies to tackle the causes and impacts of climate change at the local level. Importantly, the Declaration was co-founded and signed in the city of Nottingham, putting the city at the heart of climate change action, whilst also being the UK's first local authority initiative to combat climate change. Furthermore, the East Midlands was

the first UK region where all 46 of its local authorities became signatories, revealing the strong environmental awareness and political willingness of the wider region to tackle climate change. Evidently, a Labor administration has been beneficial to the progression of NZC and equitable transitions in Nottingham, by maintaining collective political control since 1991 with no immediate risk of change in political administration, which has allowed sustainable projects to progress.

Regarding the national institutional environment, it is notable here how actors at the local level were challenging the status quo at the time of progressing innovative and entrepreneurial energy and transport schemes. Municipal ownership has a key role to play here, with the city council going against historical privatization in both sector examples and seeking alternative and new ways of implementing projects. The impact of austerity was noted amongst several interviewees as a key challenge from an institutional level, with those highlighting the significant impact it has on resources and staff capacity to implement low sustainable projects. The entrepreneurial and innovative agency by key municipal actors was therefore fundamental in establishing new business models which could formulate place-based finance and markets, as discussed next.

5.4 Market formation and place-based finance

Nottingham city's establishment of Robin Hood Energy and the Workplace Parking Levy are examples of innovative and entrepreneurial schemes which created a market surrounding NZC transitions and perpetuating self-reinforcing growth (i.e., sustainable financial returns) for the municipality, and which go against the status quo of traditional business models.

For example, in the context of energy, municipal actors were motivated by justice concerns to provide a more affordable cost of energy supply for Nottingham residents, through the establishment of Robin Hood Energy. Despite its failings as a municipal energy company competing against privatized energy oligopolies, the municipally-owned ESCo had multiple initiatives for decreasing fuel poverty. Primarily, it operated and marketed itself as a not-for-profit energy company and therefore Nottingham City Council did not take a dividend, which allowed for the cost benefits to be passed onto the consumer: "*Our tariffs are consistently cheaper than the Big Six [energy oligopolies*" (Interview with Robin Hood Energy). The ESCo's institutional organization was noteworthy in comparison to traditional energy suppliers by not having shareholders or direct bonuses in order for the economic benefits to be passed onto the customers (Interview with Robin Hood Energy). Additionally, the ESCo offered local discounted tariffs for Nottingham residents; provisions to reduce the number of prepayment meters for consumers; voluntarily offered the Warm Home Discount Scheme; and helped the switching of void properties in its social housing. In addition to supplying 100% renewable energy from 2018, these initiatives resulted in an energy company which challenged incumbent actors and energy companies (Interview with Robin Hood Energy; NEP).

In a similar vein, the majority stake in Nottingham's transport sector is particularly beneficial for the transport system as profits can be reinvested into public transport services, with Nottingham City Council receiving a dividend from NCT of approximately £2 million per annum (Interview with Nottingham City Council). The reinvestment of profits goes toward the non-commercial services which uses electric buses and bio-methane buses owned by Nottingham City Council. The non-commercial services are predominantly networks which are deemed socially necessary, i.e., free services to support mass suburban areas, employment sites, hospital sites and to help the interchange between commercial bus services through Park and Ride services (Interview with Nottingham City Council). Such services are not commercially viable since they are not high frequency and therefore do not have a high peak vehicle requirement, however, they are particularly important for mobility justice by increasing accessibility to residents to maintain leisure, retail, and health services. which have resulted in a reduction of £4 million per annum over the past 3 years (Nottingham City Council, 2016). By plugging the gap between commercial services, Nottingham is able to serve the majority of its residents through its extensive bus network and therefore accessibility is high in the city, with a high proportion of residents (95%) living within 400 m of a 30-min peak service to the City Center, which is beneficial in terms of mobility justice and sustainable transport initiatives across the city (Nottingham City Council).

5.5 Mechanisms of path creation

The combination of municipal assets, key municipal assets, local and national institutional environments, and market formation in both energy and transport sectors enables two dominant mechanisms of path creation which catalyze NZC initiatives to emerge in Nottingham. First, the development of knowledge and expertise in the urban energy system over time, and second, the re-investment of profits from transport and energy networks into wider city services (Table 2).

The ownership of Nottingham's district heating system has enabled the Council to invest in its energy service department, through the formation of an ESCo. As such, the past establishment of district heating in Nottingham, and the continued investment in its service provision, has set a particular course in motion of societal development which affect choices into the future Whilst Robin Hood Energy was ultimately not successful as a council-owned energy company, it did nonetheless seek to present societal benefits through the re-investing of profits, visible energy pricing, with the ultimate goal of eradication of fuel poverty, paving a new narrative for the City's targets for climate change and poverty amelioration. The present-day operation of Nottingham city council's Energy Service Directorate enables the council to provide skills and expertise as a commercial service, which has been embedded over time. As highlighted: "*I think there is a uniqueness in Nottingham, the reason being if you are an authority thinking about it the other way round, you're an authority and you're looking to go where we've gone, that's a long journey and you've really got to develop a team and bring in that expertise and reputation and it would be very difficult to start from a small team or nothing to get to where we are*" *(Interview with Nottingham City Council).* The

department is particularly significant and demonstrates not only the successful expertise and knowledge developed over time, but also the weight and capacity given to these issues by the Council. Since the Energy Services department is deeply embedded within the Council and provides a commercial business and necessary income, there is less risk of this service being abolished (Interview with Nottingham City Council).

In Nottingham's municipally-owned transport sector, the introduction of sustainable buses was not from an environmental motive, but from an economic one (Interview with Nottingham City Council). This is due to the significant cost savings that are associated with switching from diesel to electric buses. For example, the fuel cost savings of an electric bus in comparison to diesel are ∼85% (with the latest UK Government Zero Emission Bus Incentive offering 22 p per km) (UK Government, 2024). Furthermore, ∼40% of costs are saved due to lower maintenance costs and no liability for Vehicle Excise Duty for electric buses. As a result, the replacement of electric buses has allowed the Council to save approximately £300,000 per annum, which is a significant cost saving in the context of budget pressures. Therefore, through the ownership of the bus network, the Council has been able to achieve two key objectives, which are cost-savings and a more sustainable bus fleet, which would be difficult under a deregulated transport sector, as it restricts the ability to mandate bus fleets in the city (Interview with UK Government).

In addition, municipal ownership of urban assets can encourage the local authority to contribute match-funding and invest in their own assets and programmes, which can signal a stronger commitment and an incentive to deliver on time and within budget. As such, being successful with funding from both UK (e.g., Department for Transport) and wider EU bodies (pre-Brexit) can have a positive knock-on effect, insomuch that the city becomes accountable for carrying out successful projects that they commit to, which allows them to make a stronger case and receive more funding (Interview with Nottingham City Council; UK Government). Such financial support has been crucial in facilitating the city's drive toward low carbon transitions, and it is evident that municipal ownership of assets when planning projects can embed the city in strong environmental and social justice commitments.

Such an interest and subsequent development in the city's transport has arguably opened up opportunities, for example with regard to funding applications. There has been a big emphasis on sustainability in the bus network in the city within recent years, with the electric bus fleet and infrastructure receiving an investment of approximately £15.1 million since 2012 (Interview with Nottingham City Council). This has enabled the city to finance 58 electric buses on 18 bus routes, one of the UK's and Europe's largest electric bus fleet. This virtuous cycle is highlighted here by one interviewee: *"If the [UK and EU] grant funding hadn't been available to purchase the infrastructure and buses, and if we didn't have the Workplace Parking Levy money available to contribute to the cost of those buses, we probably wouldn't have got into it as much as we did and as much as we want" (Interview with Nottingham City Council).*

Furthermore, the creation of the WPL is particularly appropriate here. As an innovative mechanism, the creation of the Levy provides a guarantee income for paying off the loan for the extension of Nottingham's tramline (on average £12 million per year over a 23-year lifetime; Interview with Nottingham City Council). This is particularly important given the context of budget cuts faced by the City Council, and allows excess funding to be used in the sustainable transport network, including a £50 million redevelopment of Nottingham Railway station of which £12 million was raised through the WPL from Nottingham City Council and £29.5 million from Network Rail (Catlow, 2018).

6 Discussion

This research has applied the Path Creation Framework to examine the role of municipal ownership in path creation. Using the urban case study of Nottingham, the findings showcase that municipal ownership is a key driver in the path creation process of NZC urban transitions, which is a core contribution here. Particularly, the conception of the Path Creation Framework by Mackinnon et al. (2019) has proven insightful by allowing the wider political and cultural contexts to be acknowledged at the local level, especially through the inclusion of wider institutional environments, market formulation and key actors. However, the framework has been amended for the application of sustainable transitions, leading to three distinct observations and suggestions for further conceptualization.

First, in contrast to the original framework conception which extended to international markets (e.g., Berlin and Pittsburg) (Mackinnon et al., 2019), the case of Nottingham reinforces a much more localized form of path creation. This reveals the *place-based* nature of Nottingham's sustainable pathway, repositioning the local and the municipality as a central tenet to the path creation debate This is reinforced by the application of place-based finance within "market formation," and local institutional environments and municipal assets, as opposed to wider regional and extra-regional assets and institutional environments.

Second, whilst findings support that "key actors" and their agency are path advocates (Coe and Jordhus-Lier, 2010; Mackinnon et al., 2019), the Nottingham case reinforced particularly entrepreneurial projects through which climate change is governed and creating longer-term institutional change. For instance, the Nottingham case demonstrates an example of urban infrastructure "experiments"—understood here to serve as a means for municipal actors to articulate and test new sustainable projects, and which act a critical juncture through which new socio-technical configurations take place (e.g., Coenen and Truffer, 2012; Hodson et al., 2013; Bulkeley et al., 2014). Therefore, the potential for municipal actors enabling entrepreneurial projects and experiments is a valid contribution to this framework, taking into consideration the ability of municipalities to explore and construct alternatives to the status quo whilst operating within (complying or resisting) local and national institutional environments (e.g., Featherstone et al., 2012).

Finally, Mackinnon et al. (2019) highlight the problematic language which stem from evolutionary economic geography of mechanisms of path creation (i.e., indigenous creation, transplantation, and diversification) as *"overly abstract and potentially reductionist"* (p. 124). In the case of this research the mechanisms of path creation in the Nottingham context were related to more social, temporal and economic processes, which

required a more nuanced understanding (e.g., Essletzbichler et al., 2023). Therefore, the core contribution from the Nottingham application is that the early action of individual and collective place-based actors establishing or progressing municipally-owned initiatives has been a positive development for the city through providing sunk costs, interest, learning and expertise; all drivers of which are positively self-reinforcing and enable political capacity for governing contemporary low carbon and equitable transitions in the city. These findings illustrate that the influence of municipal ownership and assets has been somewhat understated within sustainable transitions literature, in addition to reflections on political capacity and authority reflected in studies of multi-scalar governance (e.g., Bulkeley and Kern, 2006; Cumbers, 2016; Kuzemko and Britton, 2020).

Whilst this paper's case study presents a methodological limitation, it does offer potential for comparisons with other UK and developed nation city-regions. This would enable a deeper theoretical understanding of sustainable urban trajectories more globally. With the renewed emphasis on municipalities as actors and owners of assets and therefore facilitators of path creation, further research could develop the linkages between sustainable transitions and place-based path creation theory with the inclusion of justice dimensions (e.g., as highlighted by Eadson and Van Veelen, 2023) in other place-based settings in both developed and developed context in more comprehensive, comparative and longitudinal studies. Expanding these applications to not simply the energy and transport, but in addition to sectoral examples e.g., waste, housing, with attention given to insights of multi-level governance (e.g., political capacity, decision-making) would strengthen the empirical application of this evolving framework. While the Nottingham case study examined in this paper (and other studies e.g., Monstadt and Wolff, 2015) highlight the positive implications of municipal ownership, such a facilitative role should not be taken for granted across contexts and over time. As such, further research could critically examine the extent to which municipal ownership may potentially limit transition opportunities across other urban contexts, further developing the path creation framework.

7 Conclusion

This paper has combined path creation theory and sustainable urban transitions literature to further understanding of NZC transitions through three main contributions. First, its core conceptual contribution highlights that municipal ownership has been imperative for political agency and capacity to enact sustainable transitions, through being a key component in the path creation process. For example, Nottingham City Council has assets which are embedded into the city's urban infrastructure, producing positive knock-on effects for continuing momentum and implementing NZC transitions. This is facilitated by mechanisms of path creation that are not only through economic sunk-costs, allowing the city to grow on existing investment and also to re-invest profits into the urban area, but also through knowledge, skills and expertise acquired over time, which support the city's political capacity and agency to deliver schemes. Second, using the novel empirical application of Nottingham, it has taken an integrated perspective and drawn upon both energy and transport to reveal how municipal ownership—both past and present—has been particularly beneficial for the city's sustainable trajectory, and applied this through the Path Creation Framework. Third, using a Geographical Political Economy approach, this paper has appropriately placed a renewed emphasis on place-based factors, that is, the local actor and municipal agency and political capacity operating at a municipal level, and the path creation processes that have created, and continue to create, opportunities for sustainable urban trajectories. In this light, municipal ownership, agency and capacity is considered as a central tenet to the path creation and multi-scalar sustainable transition debates.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the [patients/participants OR patients/participants legal guardian/next of kin] was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

KS: Writing—original draft, Writing—review & editing.

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Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fsuep.2024.1355990/full#supplementary-material

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