Conditions for politically accelerated transitions:
Historical institutionalism, the multi-level perspective, and two historical case studies in transport and agriculture

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Abstract:
This article investigates the conditions under which policymakers are likely to decisively accelerate socio-technical transitions. We develop a conceptual framework that combines insights from historical institutionalism and the Multi-Level Perspective to better understand the political dimension in transitions, focusing particularly on the mechanisms of political defection from incumbent regime to niche-innovation. We distinguish two ideal-type patterns, one where external (landscape) shocks create a 'critical juncture', and one where gradual feedbacks change the balance of power between niche-innovation and regime. We also identify more proximate conditions such as external pressures on policymakers (from business interests, mass publics, and technologies) and policy-internal developments (changes in problem definitions and access to institutional arrangements). We apply this framework to two historical case studies in which UK policymakers deliberately accelerated transitions: the transition from rail to road transport (1920-1970); and the transition from traditional mixed agriculture to specialized wheat agriculture (1920-1970). We analyse the conditions for major policy change in each case and draw more general conclusions. We also discuss implications for contemporary low-carbon transitions, observing that while some favourable conditions are in place, they do not yet meet all the prerequisites for political acceleration.

Keywords: Socio-technical transitions; politics; acceleration; historical institutionalism; Multi-Level Perspective.

1. Introduction

This article is about the conditions under which policymakers can deliberately contribute to the acceleration of socio-technical transitions. This topic is particularly important for time-sensitive problems such as climate change, where the goal of keeping global temperature increases below 2 degrees will necessitate a dramatic acceleration of low-carbon transitions across electricity, transport, heat, industrial, and agrifood systems (Peters et al., 2017). The mainstream climate mitigation literature (IPCC, 2014; Rockström et al., 2017) has identified a range of options where strengthened policies could help accelerate low-carbon transitions, e.g. R&D subsidies, feed-in tariffs, carbon pricing, performance standards and removing fossil fuel subsidies. While useful and important, however, these studies are instrumental, focused on analyses *for* policymakers, not on analyses *of* policy.

This is problematic because scholars emphasise that the acceleration of low-carbon transitions is a deeply *political* challenge. The German Advisory Council on Global Change (2011:1), for instance, notes that while technical and policy instruments for low-carbon transitions are well-developed, it is "a political task to overcome the barriers of such a transformation, and to accelerate the change". And Sovacool's (2009:1539) review of policies for climate change mitigation concludes that: "What seems to be lacking is not the availability of robust public policy mechanisms, but the political and social will to implement them".

While tempting, a narrow focus on 'political will', or on encouraging policymakers to show courage or leadership (e.g. UN, 2016; Figueres et al., 2017), overstates the importance of politicians' own volition and downplays political scientists' argument that climate policymakers do not have perfect freedom of agency but are subject to major political constraints (Rickards et al. 2014). We therefore agree with Meadowcroft's (2016) emphasis on the "*political conditions* required to bring [low-carbon policy instruments] into play" (S16; our emphasis). This article therefore aims to better understand those conditions.

We focus on conditions under which policymakers can introduce policies that shift transitions from a "formative" phase, during which radical innovations emerge and stabilise, to a period of more rapid diffusion and breakthrough (Bento and Wilson, 2016). We are thus interested in policy changes in later phases, when policymakers accelerate transitions by "committing large scale public resources to particular technologies, or tilting regulatory or policy frameworks to favor particular approaches. (…) It is to be expected that issues will be thrashed out through broader societal debate and resolved by established political mechanisms" (Meadowcroft, 2009:337).

The paper aims to contribute to recent literature on the politics of transitions, where scholars have studied social justice and inclusion/exclusion in decision-making (Leach et al., 2010; Newell and Mulvaney, 2013), different kinds of power (Avelino and Rotmans, 2011; Hoffman, 2013), political struggles around specific innovations (Normann, 2015; Kern et al., 2015), discursive politics (Kern, 2012; Rosenbloom et al., 2016); or political resistance to transitions (Geels, 2014; Hess, 2014). Some scholars in this literature stream have started to address the political *acceleration* of transitions. Their studies identified the following conditions for political acceleration:

- The mobilization of alliances and actor coalitions (including policymakers, firms, civil society actors) around new technologies, which lobby and exert pressure for policy change (Hess, 2014; Kern et al., 2015; Markard et al., 2016a; Schmitz, 2017; Jänicke and Quitzow, 2017).
- Shifts in public opinion that influence policymakers by creating pervasive narratives that legitimise niche-innovations or discredit incumbent regimes (Raven et al., 2016;

Rosenbloom et al., 2016), or by the mobilisation of user groups as a political or economic bloc that directly shapes niche-regime competition (Schot et al., 2016).

- Technological change may also create conditions for major policy change, e.g. by providing solutions to problems, or by creating new actor networks, interests groups, or mass publics that influence policy dynamics (Schmidt and Sewerin, 2017; Lockwood 2015).

While relevant for the paper's topic, this research, likely due to its focus on renewable energy technologies, focuses mostly on endogenously created conditions for policies that support the growth of niche-innovations. They hardly engage with broader, structural conditions, which in terms of the Multi-Level Perspective (Geels, 2002; Geels and Schot, 2007), can be characterized as regime and landscape developments. Schmitz (2017: 536) recognizes this problem, noting that the alliances that support niche-innovations "operate within structures. Unpacking these structures seems essential for future research. (…) To explain this, we need to return to the big picture." Many low-carbon technologies are increasingly successful, and are emerging as serious competitors with incumbent systems (Bloomberg 2016). To meet climate goals, however, these technologies need to fully supplant established socio-technical regimes; a process for which the conditions "are only just emerging" (Meadowcroft, 2016:337). This means that a focus on the political conditions for major structural change in favour of niche technologies is a timely contribution.

Our goal is therefore to develop a more comprehensive understanding of the conditions for politically accelerated transitions at all three levels of the Multi-Level Perspective (niche, regime, landscape) as well as more specific dimensions (like pressure from interest groups, mass publics and technology). We develop an analytical understanding of radical policy change at two levels of granularity. First, we use the MLP to provide a coarse-grained account of the defection of policymakers from an incumbent socio-technical regime towards a niche-innovation. This, we argue, forms a critical tipping point in socio-technical transitions, which responds not just to action at the niche-level, but also to landscape pressures and disillusionment within the incumbent regime. Secondly, we develop a more granular understanding of the conditions for major policy change, using insights from historical institutionalism, which understands policy change as a result of political struggles between societal groups within broader institutional frameworks (Hall and Taylor, 1996). We mobilize historical institutionalism because its assumptions are compatible with the MLP, as we further discuss below (Markard et al., 2016b; Lockwood et al., 2017).

We hone these conceptual contributions with empirical research. Since low-carbon transitions have not yet sufficiently progressed, we chose two historical cases in which British policymakers decisively intervened: the transition from rail to road transport (1920-1970), which the government accelerated by building a national highway system; and the transition from traditional to modern wheat agriculture (1920-1970), which the government accelerated during the run-up to the Second World War.

The paper is structured as follows. Section 2.1 develops a coarse-grained MLP-based understanding of politically accelerated transitions. Section 2.2 discusses relevant insights from historical institutionalism to develop a more specific understanding of major policy change. Section 2.3 articulates a combined perspective that guides the empirical research. Section 3 discusses methodological issues. Sections 4 and 5 describe the two case studies. Section 6 analyses the case studies with the conceptual framework and outlines the most important conditions for deliberate acceleration. Section 7 draws conclusions, identifies limitations, and discusses generalizability and policy relevance for low-carbon transitions.

2. Conceptual framework

2.1. Overarching perspective on politically accelerated transitions

To develop a coarse-grained perspective on the topic, we start with the Multi-Level Perspective (Geels, 2002; Geels and Schot, 2007), which suggests that socio-technical transitions come about through interacting processes within and between three analytical levels: niches (the locus for radical innovations), socio-technical regimes (the rules and institutions that stabilize existing systems), and exogenous sociotechnical landscape developments, which comprise both slow-changing trends and shocks. Using the MLP, we suggest that the following three processes create conditions for the political acceleration of transitions:

- High momentum of niche-innovations, deriving from stronger supporting coalitions, technical improvements, or the articulation of positive visions and discourses (Schot and Geels, 2008; Kern et al., 2015; Raven et al., 2016; Schmitz, 2017).
- Weakening socio-technical regimes (Turnheim and Geels, 2013; Kivimaa and Kern, 2016; Roberts, 2017), which may reduce the commitment of incumbent actors (Geels, 2014) and provide windows of opportunity for niche-innovations.
- Landscape developments that put pressure on the regime or stimulate the breakthrough of niche-innovations.

While the literature already acknowledges niche-momentum and landscape pressure, the role of weakening regimes for major policy change is less developed (although Markard et al., 2016a, and Grin, 2010, mention it). In our view, however, the defection of incumbent policymakers from the socio-technical regime to the emerging niche-innovation is a crucial but under-studied mechanism for the political acceleration of transitions. Figure 1 represents this conceptual proposition with a bold arrow moving from the regime policy trajectory towards the niche-innovation. We suggest that this switch in allegiance depends not only on increasing niche-momentum, but also on the destabilisation of the socio-technical regime, which normally locks in policymakers (Geels, 2014; Hess, 2014). To develop a more granular understanding of the associated processes, section 2.2 first reviews historical institutionalism to identify more specific insights about the conditions for major policy change. Section 2.3 then combines those insights with the MLP to understand major policy change in socio-technical transitions.

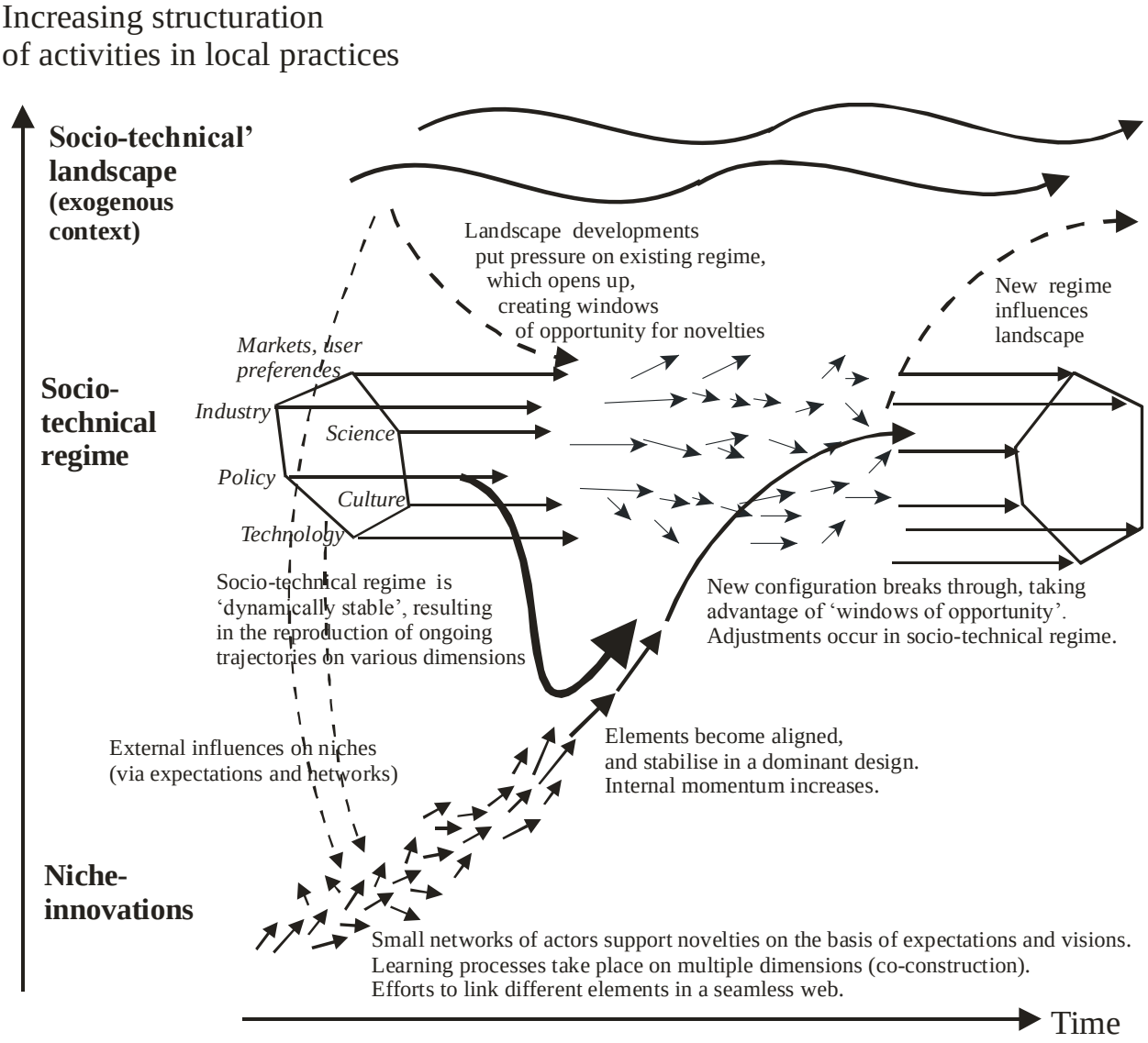

Figure 1: Conceptualizing political defection (represented by the fat arrow) in the multi-level perspective on transitions (adapted from Geels and Schot, 2007: 401)

2.2. Insights from historical institutionalism about decisive policy change

General characteristics:

Historical institutionalism (HI) is a political science approach that focuses on the meso-level of policy domains rather than individual policy instruments, and has a longitudinal orientation, often addressing decades-long processes (Thelen, 1999). Building on pluralist group theory, HI has a broad understanding of political processes as struggles between organized interest groups and collective actors (Hall and Taylor, 1996). But it adds the notion that existing policy arrangements and institutions (e.g. decision-making procedures, formal responsibilities, access and consultation rules) structure political conflict, affording some groups greater resources, influence or access to policymakers than others. Institutions are not only a strategic context for actions, but also entail "a shared set of understandings that affects the way problems are perceived and solutions are sought" (Thelen, 1999:371). Elaborating these ideas, scholars proposed the concept of 'policy regime' (Wilson, 2000; Weaver, 2010; Jochim and May, 2010), which has three elements:

- institutional arrangements, which include both policy networks (experts, bureaucrats, implementation agencies, insider interest groups) and specific procedures (e.g. responsibilities, access rules).
- shared ideas about problem definitions and policy goals ('policy paradigm').
- policy itself (plans, targets, instruments).

Existing policy regimes are the legacy of earlier conflicts and constellations (Thelen, 1999) and difficult to change, because of path dependence and lock-in mechanisms (Pierson, 2000). Policy "tends to develop in such a way that the same actors, institutions, instruments, and governing ideas tend to dominate for extended periods of time" (Howlett et al., 2009:201). Because policy regimes are usually stable, major policy change is rare.

HI is a processual approach, focusing on successive rounds of political struggles over time ('history matters'). It is also co-evolutionary and 'configurative' (Katznelson, 1997) because political processes are not studied in isolation, but in relation to social and economic developments. Major policy change tends to derive from "interaction effects among multiple institutional realms" (Pierson, 2004:136). Historical institutionalism "examines political and economic development in historical context and in terms of processes unfolding over time and in relation to each other, within a broader context in which developments in one realm impinge on and shape developments in others" (Thelen, 1999:390). The notion of *policy feedback* aims to capture these recursive dynamics, addressing not only how societal groups influence policy, but also how policy influences the interests, positions and outlooks of societal groups, thus creating new politics (Béland, 2010, Jordan and Matt, 2014). Pierson (1993) distinguished three kinds of policy feedbacks that act as lock-in mechanisms: 1) when policies create benefits for interest groups, these groups will mobilize to maintain or expand the policies; 2) political elites and agencies develop skills, administrative resources and routines that create attachments; 3) policies may affect 'mass publics' by generating interpretive efforts or patterns of behaviour (investments, skills) that are hard to reverse.

Despite these shared characteristics, HI is not a unified intellectual enterprise. Following Hall (2010) and (Bell, 2011), we distinguish two approaches in historical institutionalism that offer different perspectives on stability and major policy change, characterized as a crisis-driven pattern and a coalition-driven pattern (Jochim and May, 2010).

Path dependency approach

Leaning on technological path dependence theories (Arthur, 1989), the first HI-approach uses economistic arguments (increasing returns, sunk costs) to explain the lock-in and path dependence of policy trajectories: "Political actors develop investments, 'specific assets', in a particular arrangement - relationships, expectations, privileges, knowledge of procedures, all tied to the institution at work" (cited in Pierson, 2004:148). Policy feedbacks also lock-in interest groups and mass publics, creating irreversibilities *after* a policy has been introduced (Pierson, 1993).

This approach to historical institutionalism therefore typically relies on *critical junctures*, created by "external forces, like technological or demographic change, and large shocks, such as military conflict and economic downturns" (Hacker and Pierson, 2014:656), to unlock existing policy arrangements and enable major policy change (Capoccia and Keleman, 2007). Critical junctures are characterized by higher degrees of agency and contingency, but once political struggles and shifting coalitions result in a new policy arrangement, this will be locked-in by policy feedback mechanisms, leading to a new period of incremental change.

Critics argue that it is too easy to explain major policy change only by reference to external shocks, because this "obscures endogenous sources of change" (Mahoney and

Thelen, 2010:7), fails to "explain what precipitates such critical junctures" (Hall and Taylor, 1996:942), and also overrates the stability of existing policy regimes (Weaver, 2010). Additionally, the emphasis on irreversibility and lock-in has deterministic overtones (Thelen, 1999), leading to a shallow conceptualization of agency, which only seems relevant during critical junctures.

Agentic, power-distributional approach

The second HI-approach offers a complementary view on stability and change, which is more agentic and power-distributional (Mahoney and Thelen, 2010). It assumes that institutions differentially affect resource allocations and that winning coalitions benefit more than others. Peripheral actors or 'losers' from previous conflicts are therefore likely to contest institutional arrangements, which are best conceived as 'arenas of conflict' (Capoccia, 2016). Stability is therefore not automatic (as in the path dependence approach), but requires ongoing mobilization of political support and defence against potential challengers (Thelen, 1999). Incumbents are often well-placed to defend the status quo because of greater resources, stronger allies, and veto-players occupying critical positions (Lockwood et al., 2017).

Major policy change in this HI-approach results from struggles between incumbent coalitions and challengers, which eventually lead to major defections and policy reorientations.[1] Because these struggles involve moves and countermoves, changing coalitions and sense-making, this approach focuses on 'path creation' rather than 'path dependence' (Garud et al., 2010). It also has a broader view on policy feedbacks, which apply not only to regime stability (as in the first HI-approach), but also to path creation and new arrangements (Lockwood et al., 2017).

Major policy change becomes more likely when two developments intersect. The first development concerns the 'bottom-up' mobilization of peripheral actors and the development of alternative ideas which challenge existing policy regimes (Clemens and Cook, 1999). To advance their cause, actors aim to build coalitions, mobilize resources (including money and expertise), shape public opinion, and advocate their cause in policy debates (McAdam et al., 2001). Alternative ideas and arrangements may long remain marginal, especially when 'political opportunity structures' remain closed. 'Bottom-up' mobilization may therefore be a slow and gradual process as Pierson (2004:164) warns: "effective challenges to the institutional status quo will often require substantial time to emerge. Developments unfavourable to institutional reproduction must reach a critical threshold level that makes reform possible." Alternative ideas and arrangements may gain traction, however, when positive feedback effects generate "a virtuous cycle of interaction between policy entrepreneurs who stand to gain from a change in policy, the media who discuss an issue and public opinion which fuels the change. Each process feeds on the other. There is a bandwagon effect as a new idea takes hold. Issue expansion can become unstoppable and the momentum challenges the policy monopoly and punctuates the partial equilibrium" (John, 1999:41–42).

The second part of the explanation focuses on the strength of policy regimes, because major policy changes involve not just bottom-up mobilization, but also a "breakdown in the factors reinforcing the status quo" (Pierson, 2004:141). Policy regimes may weaken as a

[1] Some scholars in the second HI-approach also propose that major policy change can occur gradually, e.g. by layering new policies on top of old ones, changing the goals of existing policies, or altering on-the-ground implementation of existing policies (Streeck and Thelen, 2005). We do not mobilize these ideas, because of our interest in decisive policy change that accelerates transitions.

result of increasing problems (e.g. escalating costs of a policy or persistent functional problems), changing political demands from interest groups or mass publics, legitimacy crises (when people lose confidence in the old regime), or shifts in power (e.g. the dissolution of old coalitions or defection of important factions) (Wilson, 2000; Weaver, 2010).

Conditions for major policy thus arise from the intersection of two gradual developments: 1) bottom-up mobilization around an alternative institution, which gains momentum through positive policy feedbacks, and 2) weakening policy regimes due to negative policy feedbacks. These conditions enable policymakers to defect from the eroded policy regime to the alternative.

2.3. Major policy change in socio-technical transitions

Historical institutionalism is compatible with the MLP (Lockwood et al., 2017), because both share an interest in meso-level phenomena, organized collective actors, rules and institutions, longitudinal processes, co-evolution, path dependence, stability and change. From an MLP-viewpoint, historical institutionalism can therefore fulfil the role of 'auxiliary theory' (Geels, 2011) to develop a more fine-grained understanding of the political dimension in socio-technical transitions, including conditions for acceleration. The concepts in both HI-explanations of major policy change (external shocks, policy regimes, bottom-up mobilization) also resonate well with the MLP's core concepts of landscape, socio-technical regime, and niche-innovations.

One limitation of HI (and policy studies more generally) concerns technological change, which is either neglected of conceptualized as external force (as in the earlier Hacker and Pierson, 2014 quote).[2] To make HI-insights relevant for socio-technical transitions, we will rework ideas about relevant societal groups and policy feedbacks. To that end, we conceptualize policy regimes as embedded in broader socio-technical regimes (see Figure 1 and Geels, 2004). This means that policy regimes are influenced by several societal groups and by technological developments which, although socially shaped, have their own dynamics and material obduracy. This material dimension is often missing in policy studies, but obviously important for socio-technical transitions. We therefore give it separate analytical status. We therefore propose the following categories of external influences on policy regimes (which relate to niche-innovations and socio-technical regimes):

1. *Firms and associated interest groups.* Incumbent business interests tend to support the policy regimes from which they benefit through subsidies and favourable regulations (Walker, 2000). Incumbent interests are often members of institutional arrangements or have easy access to policymakers. Smaller, niche-related firms tend to have less lobbying power and policy access than incumbent firms. The 'tug-of-war' between new firms and incumbents is not only about concrete policies, but also about problem framing and policy agendas.
2. *Mass publics* is a broad category, which in socio-technical systems includes: a) users who have an interest in the proper functioning of socio-technical systems that affect their daily life (e.g. transport, food, energy), b) citizens who may make voting decisions based on their views of competing socio-technical systems, and c) public opinion and discourse which shape policy agendas and *how* issues are framed and discussed (Burstein, 2003). These sub-sections of mass publics differentially express relative preferences for niche-innovations or existing systems that exert influence on policymakers.

[2] This neglect may be due to the dominant policy studies focus on areas such as health insurance, social security/welfare, education policy, and macro-economic policy (Jordan and Matt, 2014).

Technologies and infrastructures stabilize policy regimes through their artefactual dimension (infrastructures, products, physical arrangements, or production facilities) and through their knowledge dimension (embodied in techno-scientific experts responsible for managing, developing, and improving technological systems). Increasing functional problems or escalating costs can create negative feedback loops that weaken the commitment of policymakers (Wilson, 2000; Weaver, 2010). Niche-innovations may experience positive feedback effects like increasing returns (scale economies, learning-by-doing, network externalities) that improve price/performance characteristics (Arthur, 1989), which, in turn, may stimulate consumer interest, business growth, positive discourses that increase the strength of niche-related policy demands.

Two ideal-type patterns

Based on these analytical considerations, and drawing on the HI-literature, we propose two ideal-type patterns for major policy change and defection.

The first (crisis-driven) pattern corresponds to the "critical junctures" pattern, in which external (landscape) shocks disrupt the existing socio-technical regime and cause major crises (e.g. functional-technical problems or business collapse). The rapid change in policy agendas and problem definitions leads policymakers to abandon the existing policy regime. If a viable alternative (e.g. a niche-innovation with a stabilized dominant design) is available, policymakers will reorient towards it and introduce policy instruments to accelerate its diffusion. The creation of new institutional arrangements (e.g. agencies, committees) and the enrolment of societal groups (industry/business, users, scientists, mass publics) may then *follow* the implementation of new policies, in order to create policy feedbacks and ensure lock-in (Pierson, 1993). If no obvious or viable alternative is available, policymakers are likely to engage in a frantic search and innovation process (Sine and David, 2003).

The second (coalition-driven) pattern corresponds to the agentic, power-distributional pattern, in which policy regimes experience external pressures from two coalitions, associated with the existing socio-technical regime and the niche-innovation. Conditions for major policy change arise gradually from two intersecting trajectories: 1) niche-related demands for policy change increase because of 'empowerment dynamics' from expanding coalitions (business, mass publics, scientists) (Kern et al., 2015; Raven et al., 2016) and technological increasing returns (Arthur, 1989), 2) stabilising pressures weaken when socio-technical regimes face persistent technological problems (e.g. technical bottlenecks or functional problems that require public investments), poorly performing incumbent firms (which lose political clout if they shrink or require continuous subsidies), disenchantment of mass publics (e.g. user dissatisfaction with existing technologies and negative discourses).

As long as both external pressures remain below a certain threshold, policymakers will remain committed to existing policy regimes. But when both external developments continue, this will, at some point, affect policy regimes leading to changes in ideas (problem definitions and policy goals) and institutional arrangements (e.g. altered policy access for new and incumbent actors). The combined effect of changing external pressures and altering policy regimes creates the conditions for political defection and comprehensive policy change. Compared to the first pattern, where policymakers play a leading role after a crisis, they are initially more hesitant in the second pattern, and only introduce decisive policies in response to increasing external pressures and policy-internal developments.

To sum up, then, we see policy as being influenced by three kinds of societal groups (business interests; mass publics; experts) and by technological developments. Under ordinary circumstances, regime-level pressures from these categories lock policymakers into policy regimes, which militate against major policy change. Sometimes, however, the balance

of power changes in ways that make it possible, and even necessary, for policymakers to defect and switch toward niche-innovations. This can occur under two kinds of conditions: 1) a sudden landscape shock that undermines incumbent socio-technical and policy regimes; 2) the gradual weakening of socio-technical regimes and strengthening of niche-innovations, which change the balance of external pressures on policymakers; when combined with policy-internal changes in institutional arrangements and problem definitions, the conditions are ripe for major policy change. Policy feedbacks can play a substantial role in this second pattern, with policy developments influencing the different groups and technologies associated with niche-innovations and existing regimes, which in turn alter political conditions.

3. Methodology

We will further explore our research topic and framework with two historical case studies, each of which explores the conditions that enabled deliberate political acceleration of a socio-technical transition. We choose a case study methodology, because the research phenomenon is complex and context-dependent (Flyvbjerg, 2006). We use historical case studies, because this enables a study of whole transitions, including acceleration and diffusion, which is not yet possible for contemporary low-carbon transitions. We choose a comparative methodology, because this enables a study of different patterns, deriving from varying interactions between core processes. The two cases are the transition from a rail-based transport system to a road-based transport system (1920-1970) and the transition from traditional mixed agriculture to specialized wheat agriculture (1920-1970). Both cases took place in the United Kingdom, which allows fruitful comparison. In both cases policymakers acted decisively to accelerate the socio-technical transition, switching their allegiance from the old to the new system. The conditions for major policy change are likely to vary between the cases, because a major landscape shock (World War II) was important in the agricultural transition, while the transport transition involved prolonged struggles between railway regime and road transport niche. We will investigate if both cases followed the two ideal-type patterns specified above and how the more granular causal mechanisms played out over time.

As data sources we used statistical databases and secondary historical studies which provided general information about the transitions and more specific information about policy-internal developments. These studies were found using keyword searches in journal databases, and a snowball approach, in which references in each text were used to find more references. We identify two periods in each case: a formative phase, where the new system existed in market niches but was not expanding rapidly, and an acceleration phase, where the transition was deliberately sped up. This strategy enables in-depth investigation of the conditions and processes in the tipping point, when decisive political action accelerated the transitions from one phase to the other.

The case studies are organised to explain the emergence of the conditions for major policy changes that accelerated socio-technical transitions. For each phase we focus subsequently on regime and niche-innovation. In line with our conceptual framework, we describe three roughly sequential developments: external pressures on policymakers (from businesses, mass publics, and technology); policy developments (including ideas, institutional arrangements, and actual policies); and the subsequent feedback effects of policy changes on the development of the transition.

4. Case study 1: The UK transition from a rail to road-dominated transport system (1919-1970)

The formative phase in the transition from a rail-dominated transport system to a road-dominated transport system took place during the inter-war period, when road transport had a stable market niche, but car ownership had not yet expanded into the middle classes and the country remained largely dependent on railways. During this period, policymakers' approach to transport was mainly to correct harmful externalities such as car accidents or railway monopolies. There was little in the way of a coordinated policy aimed at shaping the evolution of the British transport system. The transition towards road transport advanced after the war, with an inflection point in the mid-1950s (Figure 2). The government accelerated this unfolding transition by building a national highway system, with the first stretch opened in 1958. By 1970, the country had finished its 1000th mile of motorway, and the railways had been drastically cut.

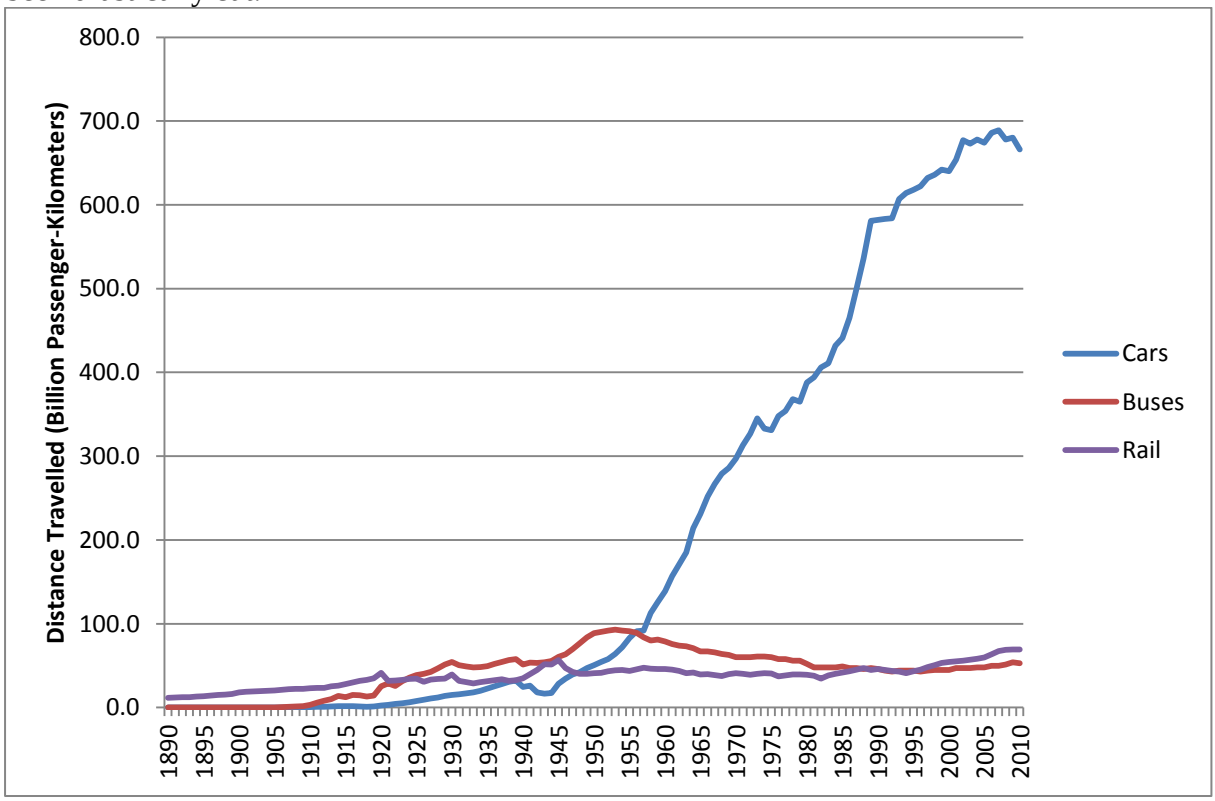

Figure 2: The evolution of British passenger transport, 1920-1970 (based on data from Fouquet, 2012)

4.1. Formative phase (1919-1945)

Policymakers during this period acted on a policy paradigm which saw their primary goals as limiting the worst problems caused by each mode of transport, rather than to deliberately support any one mode of transport. Two dynamics were important in this phase. Firstly, the railways, weakened by the First World War and losing their political influence, were forced to compete with road transport on unequal terms. Secondly, and partly due to the first point, the road lobby increased in power, successfully advocating for regulatory preference, and for some of the county's first trunk roads. The maturing of the road transport system and the erosion of the railways were thus the critical developments of this phase. Their later political impacts would eventually swing policymakers to decisively support road transport over rail.

Railway regime

Pressures on policy from system: The railways faced serious problems after the end of the First World War, which had badly damaged their infrastructure, leading to subsequent persistent financial problems (Aldcroft, 1975; Dyos and Aldcroft, 1974). Partly due to this, and partly due to the railways' history of monopolism, the railways also faced distrust and dissatisfaction from mass publics, who decried the railways as irresponsible and obstinate monopolies, creating pressure on policymakers to curb their excesses (Roberts, 2015).

Policy developments: At the end of the First World War, policymakers were motivated by a belief that the railways had done well under common ownership during the war, and an assumption that the railways would retain their monopoly on surface transport, and that their monopolistic power should therefore be curbed (Aldcroft, 1975; Bagwell, 1988). The idea of railway nationalisation therefore enjoyed a brief popularity in the newly created (1919) Ministry of Transport, before being blocked by lobbying from road transport interests (discussed below). Instead, the Conservative government's 1921 Transport Act grouped the railways into five private regional monopolies, which were subjected to strict restrictions on their ability to set fares (Aldcroft, 1975; Bagwell, 1988).

These regulations created severe problems for railway managements as they struggled to compete with road transport. Although railway interests lobbied for a fairer regulatory framework, policymakers only granted slight concessions because they were still motivated by continuing distrust of the railways (Bagwell, 1988; Dyos and Aldcroft, 1974). In 1938, the railways' Square Deal campaign convinced the Transport Minister to reduce the railways' regulatory burden, though he was unable to act before the outbreak of the Second World War (Dyos and Aldcroft, 1974).

Effects of policy on system: The 1921 Transport Act led to a one-sided competitive situation with the increasingly powerful road transport industry, whose operators were able to undercut the railways. The railways' attempts to reduce their regulations, increase regulations on road transport, or get on the roads themselves, were all undermined by political opposition, and though the railways won some victories, these were not enough to stop buses and lorries from undercutting trains (Bagwell, 1988; Dyos and Aldcroft, 1974). Without change to their regulatory disadvantage, the railways had few options to compete with road transport, meaning that the interwar period was one in which they weakened as a political, commercial, and technological force.

Road transport niche

Pressures on policy from system: After the First World War, cars improved in speed, range, and reliability, while coming down in price. This allowed car ownership and road transport to develop "social depth" (Church, 1994), as the use of private cars expanded outside the upper classes (Walton, 2011), while those who could not afford their own cars took advantage of a growing bus and lorry industry, which was further bolstered by the regulatory constraints on the railways (Aldcroft. 1975; Scott, 2002). These developments were supported by positive discourses associating road transport with speed, freedom, adventure, and progress (Jeremiah, 2007; Merriman, 2011; Moran, 2010; Roberts, 2015).

The combined effects of these developments were three-fold. Firstly, road transport grew as a commercial force and technological system, attracting more travellers and developing cheaper vehicles, new infrastructures (such as trunk roads and garages), and new user practices. Secondly, the growing road industry further developed its political arm, consolidating into umbrella organisations such as the British Roads Federation. The road lobby was still fragmented and largely ineffective, but they did manage to promote some of

their ideas (discussed below) through deputations on government committees, and the placement of their own people into prominent government positions, such as William Joynson-Hicks, who founded the Automobile Association and became Home Secretary in 1924 (Hamer, 1974; Cox, 2012). Thirdly, increasing numbers of cars on the roads created new problems, such as the accidents and rural blight , which created pressures on policymakers.

Policy developments: After the war, the roads lobby won an important battle over the composition of the newly formed Ministry of Transport, "ensuring that roads and rail remained separate sections in the Ministry" (Wolmar, 2016:20). The roads section developed a policy orientation that saw road construction as a viable solution to problems, such as rural blight and accidents (Dudley and Richardson, 2000). This, along with road industry lobbying, led to many major trunk road schemes in the 1920s. Though many of these failed to secure funding, key policy ideas that were favourable to road transport became prominent in government circles. As more trunk roads were built, a prominent expert community of surveyors and highway engineers developed within the Ministry (Dudley and Richardson, 2000). The participation of many highway engineers and county surveyors in a British Roads Delegation to see the German *Autobahnen* in 1937 inspired many in this community to endorse a British motorways programme. By the end of the 1930s, transport experts had reached the consensus that road transport's teething problems should be solved by fitting the roads to the traffic, rather than vice-versa.

Effects of policy on system: There was a direct policy feedback effect between the continuing growth and success of the road transport system and the growth of the political forces that favoured it, including actors outside of government (driving clubs and lobbyists for road transport industries) and actors inside of government (such as cabinet ministers and departmental experts). As policymakers continued to restrict the railways and give concessions to the road lobby, the road industry succeeded even more, leading to an even stronger lobby for further policy concessions (Scott, 2002; Hamer, 1987).

4.2 Acceleration phase (1945-1970)

After the war, the railways continued to decline in commercial, technological, and political power, while the road transport system continued to grow on all three dimensions. This continued to shift the balance of power in transport policy, as the Ministry of Transport became increasingly positive about the ascendant road regime, with pro-road transport ministers of both major parties finding ways to court the support of other government departments, including, most importantly, the Treasury. This eventually led to two decisive policy interventions: the construction of a national motorway system, which massively increased government spending in both absolute and relative terms (Figures 3 and 4), and dramatic cuts to the railways. These two policy interventions cemented the dominance of the road transport regime, and dramatically accelerated its diffusion.

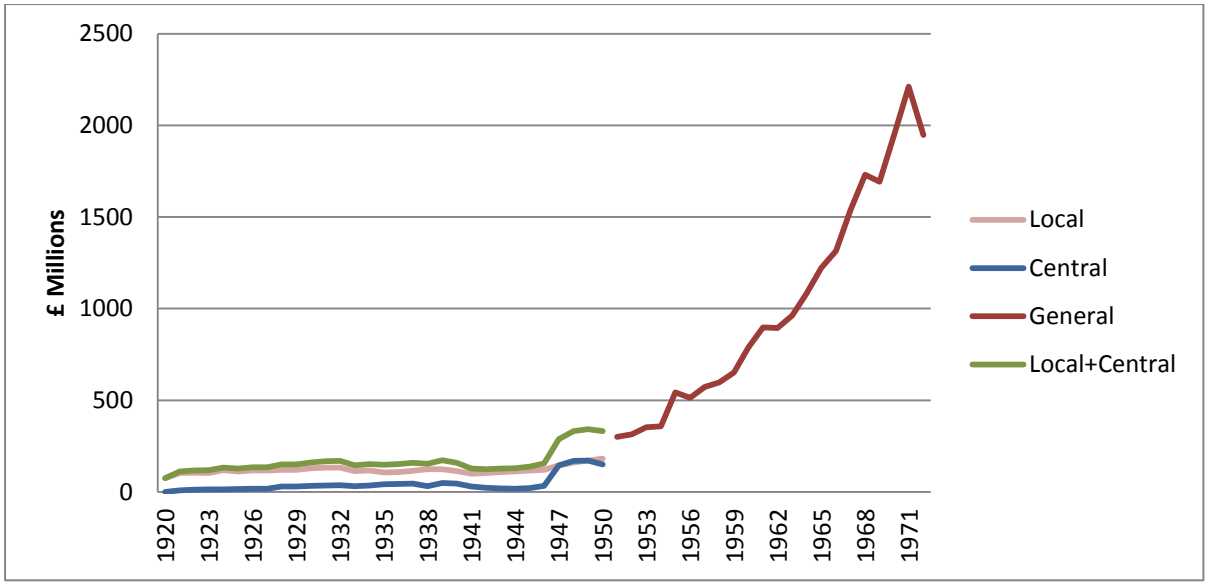

Figure 3: Total government spending on transport, 1920-1972 (based on data from Chantrill, 2016 and Mitchell, 2011)[3]

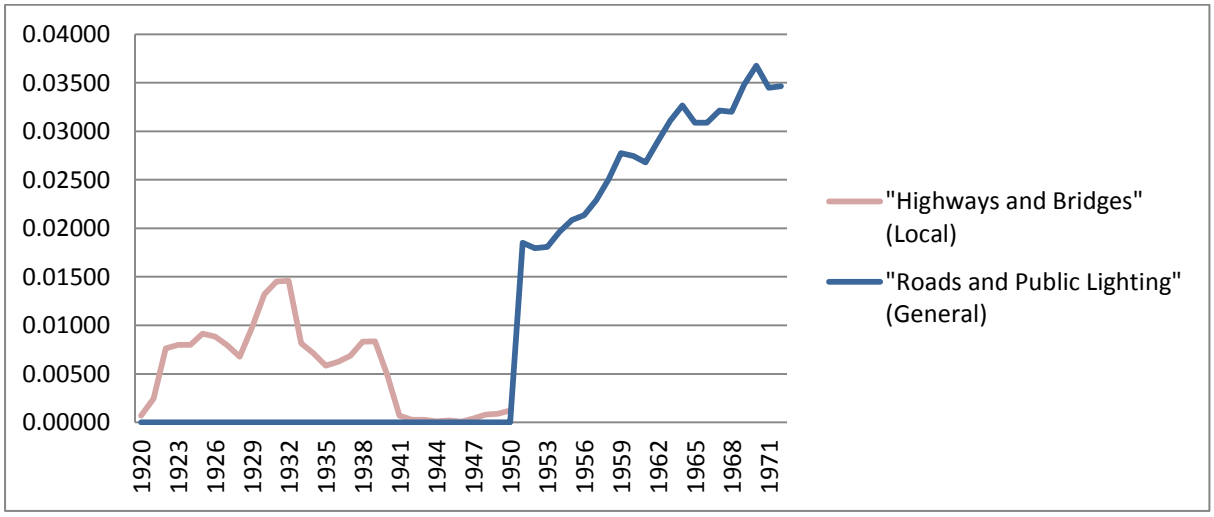

Figure 4: Spending on roads as a proportion of total government spending, 1920-1972 (based on data from Chantrill, 2016 and Mitchell, 2011)

Declining railway regime

Pressures on policy from system: The railways exited the Second World War badly undermined by war damage, facing major financial shortfalls, and still subject to many of the same regulations they faced in the interwar period (Dudley and Richardson, 2000). Meanwhile, travellers and shippers, frustrated by poor railway service, deserted the railways for the roads (see below), further exacerbating economic problems (Bagwell, 1988). Mass

[3] Budgeting *processes* changed in 1951. Prior to 1951, budgets were divided into local spending (which accounts for the total spending of all British local authorities), and central spending (which accounts for spending by the government in London). After 1951, this was amalgamated into a single category of general spending. Budget *categories* also changed in 1951, with road spending prior to 1951 being included under a 'highways and bridges' category of local budgets, and in a 'roads and public lighting' category of general budgets after that year.

publics continued to express frustrations with railway service, increasingly decrying it as a Victorian relic (Roberts, 2015). The various railway interests (operators, labour unions, machinists) did not mount an effective counter-lobby because they "lacked a coherently organised core of actors with agreement on values and goals" (Dudley and Richardson, 2000:27).

Policy developments: The post-war Labour government nationalized the railways and common road carriers under the British Transport Commission (and later British Rail), which was originally intended to coordinate both systems (Bagwell, 1988). But road transport was re-privatised in 1951, while British Rail remained in government hands (Bagwell, 1988; Hamer, 1987). As the British Transport Commission found itself "overwhelmed with complex responsibilities" (Dudley and Richardson, 2000:36), they were unable to come up with a viable long-term commercial railway strategy.

The first attempted solution to these problems was based on the idea that the railways could improve their situation by modernising tracks and locomotives to increase revenues (Dudley and Richardson, 2000). The resulting 1955 modernisation programme, however, was beset with delays, cost overruns, and technical controversies (Bagwell, 1988; Bonavia, 1981). The railways' continuing dependence on government subsidies started to create frustration among policymakers (Bonavia, 1981), which in the late 1950s led Transport Minister Ernest Marples to adopt a new strategy and policy paradigm, which saw major railway cuts as the best way to achieve financial viability. To sidestep established interests and policy communities which might resist this policy, Marples abolished the British Transport Commission, replaced its railway section with the British Railways Board, appointed outsider businessman Richard Beeching as head of the board, and gave Beeching political support through public statements and white papers. In 1963 Beeching announced a massive programme of cuts, particularly in smaller lines and stations.

Effects of policy on system: Beeching oversaw a massive scaling-back of the British rail infrastructure. By 1968, British Rail's supply of rolling stock and the number of stations were halved, while 5,000 miles of track were closed. This left many communities entirely dependent on the roads for basic transport needs (Aldcroft, 1975).

Ascending road transport regime

Pressures on policy from system: After the Second World War, economic prosperity and cheaper vehicles, combined with positive discourses associating cars with modernity and success, led to a booming in private car use (Figure 2; Foreman-Peck, 1995; Jeremiah, 2007). The growing numbers of cars created more demand for road space, while businesses, such as car manufacturers, road construction firms, and bus and lorry companies, continued to expand rapidly (Moran, 2010; Church, 1994), empowering the road lobby to push for more road construction (Hamer, 1987). Already in 1943, the British Road Federation adopted a target of 1000 miles of motorways, which they subsequently promoted using dioramas, displays, illustrations, and campaigns for local support for particular road projects (Hamer, 1987; Merriman, 2011). Mass publics and journalists, meanwhile, adopted high modernist discourses portraying motorways as exciting and futurist, often castigating the government for its slow progress in building motorways (Roberts, 2015). Motorways were also pushed by the increasing prominence of functional problems such as congestion, brought on by the increasing numbers of cars.

Policy developments: By the end of the Second World War, policymakers were enthusiastic about the general vision of motorway construction as a way to encourage post-war economic development and embrace technological progress (Merriman, 2011; Dudley and Richardson, 2000). This enthusiasm is evident in a number symbolic choices, such as the display of the

County Surveyors' Society's 1000 mile motorway map in the House of Commons Tea Toom, or the passage of a Special Roads Act in 1949 (Moran, 2010; Dudley and Richardson, 2000). But concrete plans and implementation were hindered by severe post-war financial pressures, which meant that little progress was made on motorways in the first post-war decade (Dudley and Richardson, 2000).

That began to change with the appointment of Transport Ministers Watkinson (1955-1959) and Marples (1959-1964), for whom motorway construction offered a tidier, more appealing, and electorally popular (Figure 5) solution to transport problems than grappling with the railways' vexing difficulties (Dudley and Richardson, 2000). In the mid-1950s, Watkinson cultivated the alliance of road businesses as well as other departments, particularly the Treasury, by making reference to the political importance of motorways (Dudley and Richardson, 2000). The idea that there were 'votes in roads' convinced the Cabinet to approve large expenditures for motorways. The completion of the Preston Bypass and the M1 in the late 1950s (Merriman, 2011) generated major public excitement. In 1962, Marples, a former road builder, announced a target of 1000 miles of motorways, which was achieved ten years later (Moran, 2010).

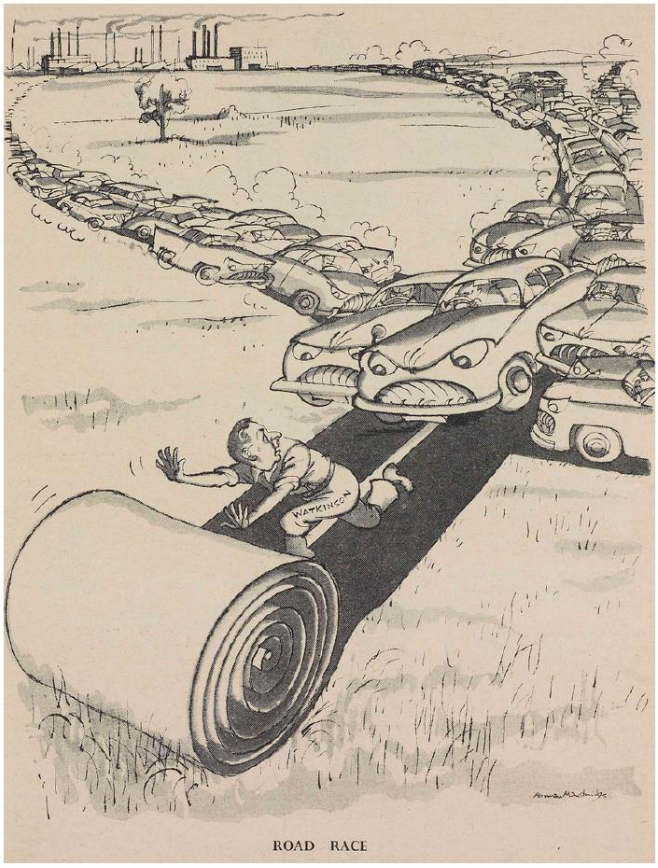

Figure 5: A 1959 Punch cartoon illustrating Transport Minister Harold Watkinson unrolling roads for an eager queue of cars, illustrating the political demand for new roads. (Mansbridge, Norman. "Road Race." Punch Historical Archive, London, England, 19 Aug. 1959: n.p. Punch Historical Archive. Web. 4 Sept. 2017)

The popularity of motorway projects made them a standard policy solution, and required the Ministry of Transport to expand the community of road-building experts within its offices (Roberts, 2015; Dudley and Richardson, 2000). This policy community, the easy access of road lobbyists to institutional arrangements, and the unwavering support of both political

parties made motorway construction the standard policy solution into the 1980s (Vigar, 2001).

Effects of policy on system: The reorientation of policy preference from railways to roads helped the expansion of road transport businesses, which in turn further strengthened and emboldened the road lobby to push for yet more road construction (Church, 1994; Hamer, 1987). Motorways were accordingly built at a rapid pace throughout the late 1950s and 1960s, and became the country's dominant transport infrastructure (Moran, 2010).

5. Case study 2: The UK transition from mixed farming to modern wheat agriculture (1920-1970)

Before the Second World War, wheat was grown as part of a mixed agricultural system, in which cleaning crops, such as turnips or parsnips were grown as livestock feed and to eliminate weeds and pests. Manure was then used as the primary fertiliser (Grigg, 1989; Petersen, 1995). For grain supply this system was marginal: in 1936, the country relied on foreign supplies for 88 percent of its wheat, and the vast majority of all wheat was intended for human bread consumption (Wilt, 2001; Cauvain and Young, 2006). This meant that prior to the Second World War, the incumbent wheat regime effectively had two components: a badly degraded *domestic farming* regime whose products were mainly used as livestock feed (Cauvain and Young, 2006); and a wheat *importation* regime, which enjoyed political privilege due to the importance of free trade for the export of British industrial products (Grigg, 1989).

This changed during the run-up to the Second World War, as the British government, concerned about wartime food security, accelerated the development of a modern, specialised wheat agriculture regime dependent on mechanical and chemical inputs (Grigg, 1989). This transition can be seen quantitatively through wheat yields and the increasing use of technological inputs (Figures 6, 7, 8, 9).

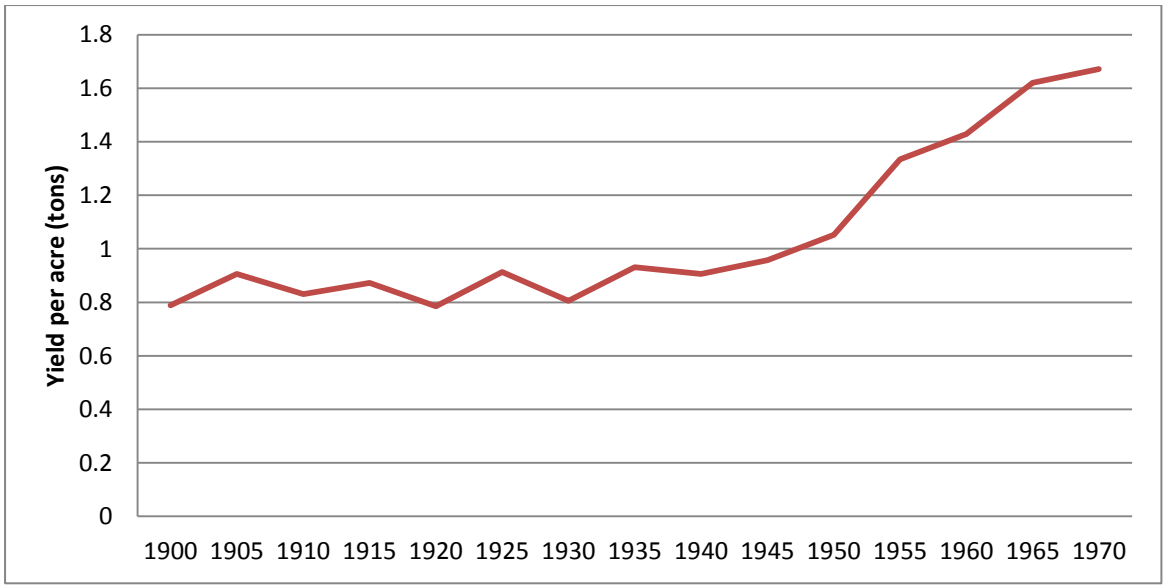

Figure 6: Wheat yields per acre in the United Kingdom, 1885-1970 (data from Mitchell, 2011)

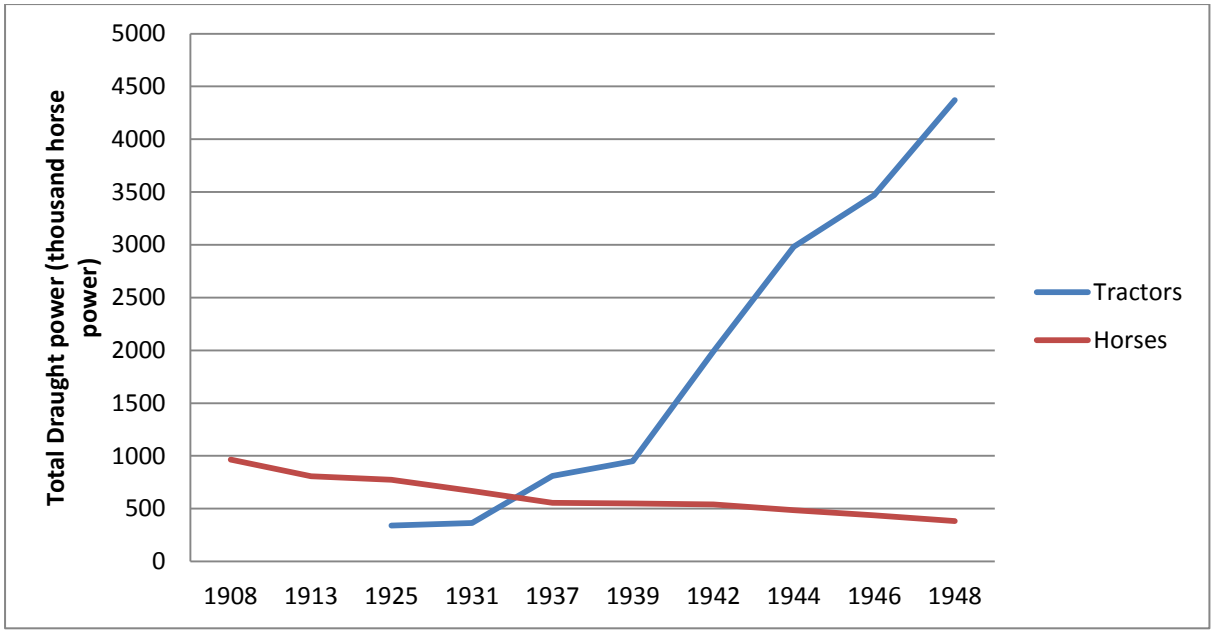

Figure 7: Farm draught power (in horsepower) in England and Wales, 1908-1948 (data from Holmes, 1985)

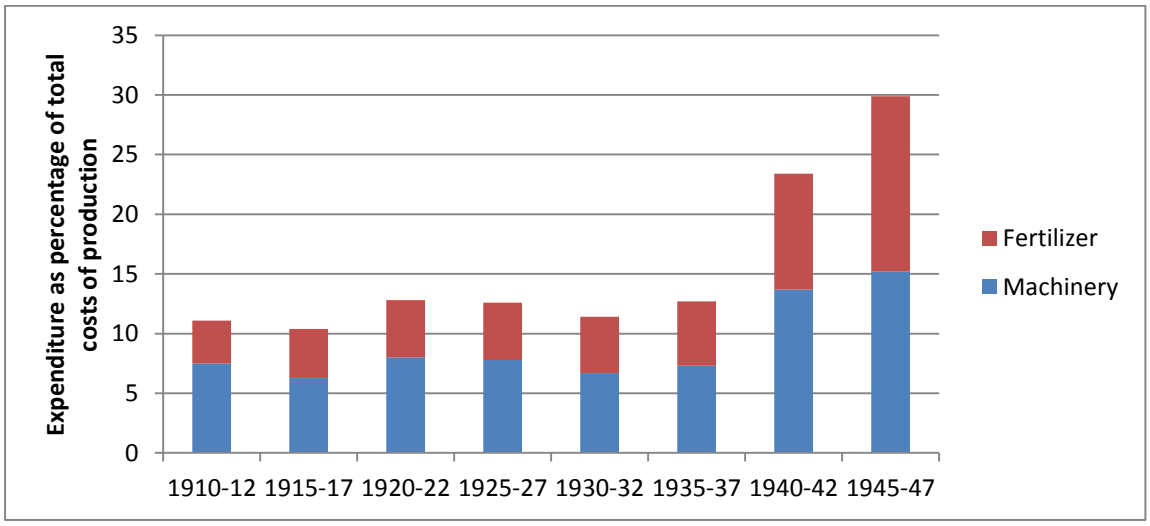

Figure 8: British farmers' expenditure on technological farm inputs, 1910-1945 (data from Holmes, 1985)

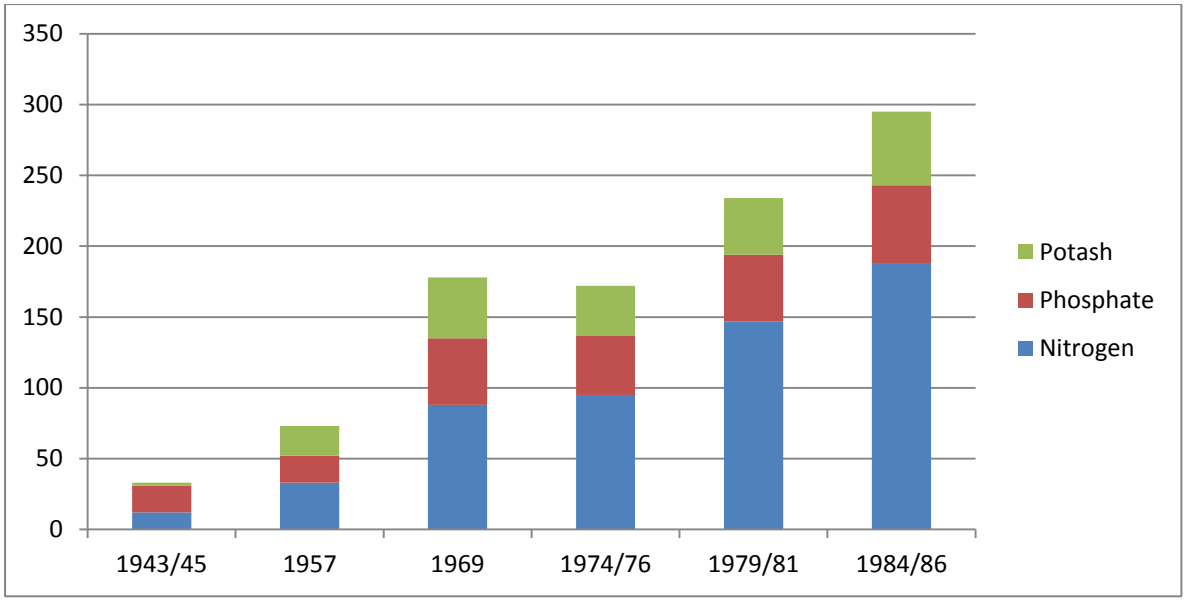

Figure 9: Overall rates of fertilizers applied to winter wheat in England and Wales (data from Martin, 2000).

5.1 Formative phase (1919-1938)

Incumbent mixed-farming and import-based regime

Pressures on policy from system: Britain in the 1920s was in the midst of an agricultural depression, brought on largely by free trade policies leading to the mass importation of cheap grain, which depressed prices (Figure 10) and reduced investment, leaving British farmers largely dependent on a traditional system of mixed agriculture as described above, and leaving many of them facing foreclosures and unemployment (Grigg, 1989, Holmes, 1985). This system was also locked in by the immature state of early farm machinery, which still had unsolved technological problems, and was poorly suited to the physical arrangement of British farms. This was particularly true in heavy soils, which would have been ideal for tractors, but which, due to the lack of investment, could not be adequately drained (Whetham, 1970; Brassley, 2000; Martin, 2000).

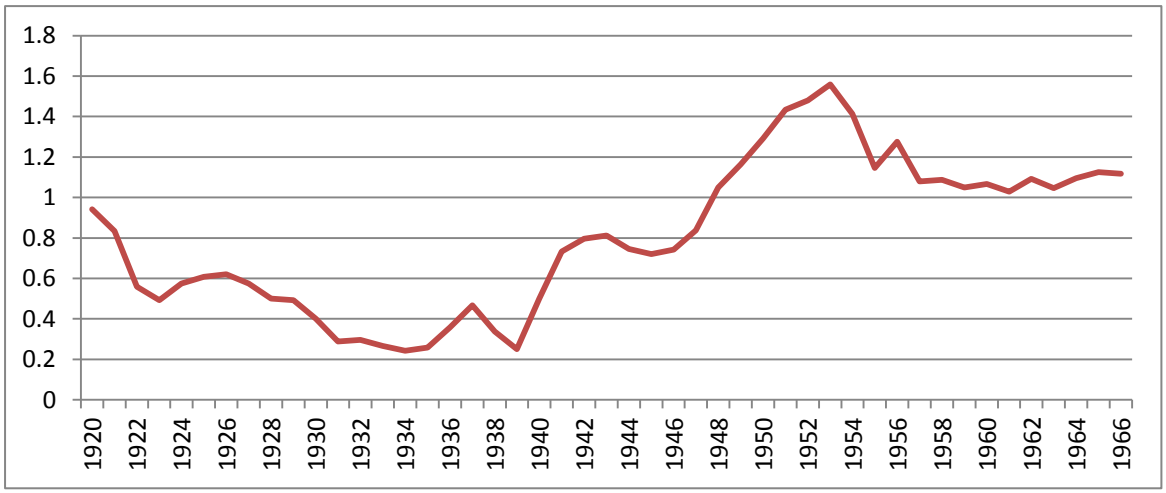

Figure 10: The price of wheat per hundredweight, 1920-1966 (data from Ministry of Agriculture, Fisheries and Food, 1968)

The commercial pressures on British farmers, as well as general public concern about the state of the rural landscape, created political unrest, leading Minister of Agriculture Noel Buxton to call a 1930 conference with agricultural interests. When the resultant minor policy tweaks did not solve the problem, rural unemployment became an issue in the 1935 general election (Wilt, 2001). Meanwhile, the National Farmers Union (NFU) was building political capital, building up its membership in the 1930s and creating alliances to establish itself as the dominant agricultural advocacy group (Smith, 1993). These pressures were initially blocked by wheat-exporting foreign governments, who exerted an important influence on UK policy due to the British government's reliance on industrial exports (Wilt, 2001).

By the late 1930s, however, as the threat of war loomed on the horizon, the government began looking at agricultural support as a wartime necessity. This allowed the NFU to build closer relationships with the government (Cox et al., 1986), providing it with opportunities to advocate increased domestic production, guaranteed prices, and modernisation as a solution in the event of war (Wilt, 2001).

Policy developments: Despite political pressures over agricultural policy, grain exporting nations' diplomatic trump card proved decisive, and ultimately the government only offered piecemeal assistance to farmers, such as a short-lived price guarantee in 1920, a subsidy scheme in 1924, and arterial drainage grants which were ineffective due to not being linked to drainage schemes in individual fields (Brassley, 2000; Grigg, 1989).

During the 1930s, as the pressures on the system increased due to the impacts of the Great Depression, the government began consulting more closely with agricultural interest groups, holding regular conferences and meetings with the National Farmers' Union, the Central Landowners' Association, agricultural labour unions, and other related groups. This established a new set of policy ideas, saying that the government should maximise production and stabilise prices by means of deficiency payments (Smith, 1993; Wilt, 2001). These policy ideas were somewhat realised in the 1932 Wheat Act, which gave farmers a deficiency payment, financed by a levy on flour. But this policy did not encourage any technological change or remove the pressure of foreign imports, and so still remained within the free-trade policy paradigm (Wilt, 2001; Smith, 1993).

It was only in the late 1930s, as war with Germany appeared more likely, that agricultural interest groups (particularly the NFU) gained greater access to institutional arrangements, as the government began consulting about policies to increase domestic production (Cox et al., 1986). Farming groups were given prominent spots on policy committees and in consultations (Wilt, 2001), which led to the formalisation of new policy approaches. In 1937, the Ministry of Agriculture announced its intention to bring about a 10% increase in wheat production and to implement a price insurance scheme for wheat and oats (Smith, 1993).

Effects of policy on system: Due to the piecemeal nature of British policy measures during this phase, not much changed in the agricultural regime. British farms continued to be starved of investment, leading to only limited uptake of modern agriculture, and continued reliance on imports. In 1939, 88% of British wheat was imported (Wilt, 2001).

Modernised wheat agricultural niche

Pressures on policy from system: Modern wheat agriculture was a small niche-innovation in the UK at this time. While technologies such as combines, fertilisers, tractors, and herbicides had begun to diffuse widely in other countries such as the United States (Grigg, 1989; Holmes, 1985), their use was limited in the United Kingdom, due to the aforementioned lack of investment, technical problems, and physical arrangement of British farms (Grigg, 1989; Holmes, 1985). Tractors were less flexible and more expensive than horses; their wide

turning radius caused problems on small British farms; and there was a shortage of implements and servicing facilities to support them (Whetham, 1970). Tractors also needed supplementary machines such as combines to be used most effectively for wheat farming. While some of these difficulties were mitigated by technical improvements over the interwar period, others were not, making tractors unattractive for most British farmers. Due to the limited diffusion of these technologies and techniques, niche actors had little political influence.

Policy developments: Policymakers took little interest in modernised agriculture during this period and apart from the aforementioned drainage schemes, did little to promote it. The most they achieved was a series of research centres providing scientific advice on pest control and fertiliser. They also began to develop a system of expertise related to intensive, industrial agricultural methods, though few farmers were inclined to listen (Holmes, 1985). By 1936, as the threat of war began to appear more urgent, the government implemented some piecemeal adjustments to the existing system, such as grants for drainage or for lime and slag, or a campaign against animal disease (Smith, 1993).

Effects of policy on system: Modern agriculture continued to spread slowly. Combines first appeared in Britain in 1928, but by 1939 there were just one hundred of them (Brassley, 2000; Whetham, 1970). Other inputs, such as fertiliser and pesticides, were largely provided for by the mixed style of agriculture that was still dominant. Most British farms during the 1930s produced at least 10 commodities and sold at least 5 (Grigg, 1989), meaning that for many farmers there was little reason to use artificial inputs.

5.2 Acceleration phase (1938-1970)

The Second World War accelerated the transition, because the government introduced drastic policy interventions to increase domestic production and reduce the country's reliance on foreign grain. The choice of specific policy instruments was heavily influenced by agricultural interests, and ultimately had two impacts: they reduced the risks and provided the means for farmers to invest in machinery and land improvements. These changes, along with deliberate government promotion, and in some cases coercion, stimulated farmers to adapt their farms to modern methods, abandoning mixed agriculture in favour of wider use of machinery, pesticides, and fertilisers.

Disrupted incumbent wheat regime

Pressures on policy from system: The 1938 Czech crisis led to a preference for more interventionist food policies (Wilt, 2001). The actual outbreak of war physically disrupted the food importation regime, both due to the need for ships to transport war material and the threat of German submarines (Cox et al., 1986; Grigg, 1989). Disrupted food imports created existential threats and a high sense of urgency to modernize domestic wheat farming. More agricultural machines were needed because it would take too long to rear new horses, and because labourers were required for the military (Wilt, 2001; Grigg, 1989).

Policy developments: While the government made some new arrangements with (allied) grain exporter nations such as Canada and the United States, the war disrupted their implementation (Wilt, 2001). Instead, the government opted to boost domestic production through a modernisation campaign.

Effects of policy on system: The physical and political breakdown of the food provision regime created a 'critical juncture', which facilitated the transition discussed below.

Specialised wheat agriculture regime and policy lock-in

Pressures on policy from system: War-time disruption of food imports necessitated a large boost to domestic food production. The NFU achieved a privileged place in policy circles, as was signalled in 1939 when Sir Reginald Dorman-Smith, a former president of the NFU, was made Minister of Agriculture (Wilt, 2001). The transition to a modern wheat agriculture regime led to the expansion of an agricultural supply industry, providing fertilisers, machines, and pesticides, which developed their own lobbying capacity, thereby further shaping government agricultural policy after the war (Grigg, 1989; Martin, 2000).

Policy developments: As the government made explicit preparations for war, a new interventionist policy paradigm emerged, based on three goals: 1) maximizing domestic production, 2) keeping prices reasonable for consumers, and 3) providing certainty and stable incomes for farmers (Bowers, 1985). Policymakers used a range of instruments in pursuit of these goals, including War Agricultural Executive Committees to manage food production at the local level; capital grants and cheap loans for machinery and land improvement; the direct purchase of equipment such as tractors; the creation of stable markets with fixed prices; and technological extension schemes (Bowers, 1985; Grigg, 1989; Martin, 2000). This put farmers, whose cooperation was essential for these changes to work, in an extremely strong negotiating position, and so farming organisations became directly incorporated in the decision-making process, with the NFU in particular becoming a "right hand" to the Ministry (Wilt, 2001).

By the end of the war, the ideas at the core of this policy programme had become stabilised, partly due to the proactive strategies of farming organisations, such as a 1944 declaration by a large coalition of agricultural lobby groups arguing for the continuation of secure prices, credit facilities, and government assistance after the war (Cox et al., 1986). The government largely acceded to these demands. The 1947 Agriculture Act guaranteed the NFU consultation on all agricultural policy, excluding other groups, and provided for the continuation of county councils, on which the NFU would continue to have a large impact (Cox et al., 1986; Smith, 1993). This further entrenched government spending (Figure 11) and an ideology of expansion, which relied on technical efficiency to maximise production, and which remained unquestioned until the late 1970s (Smith, 1993).

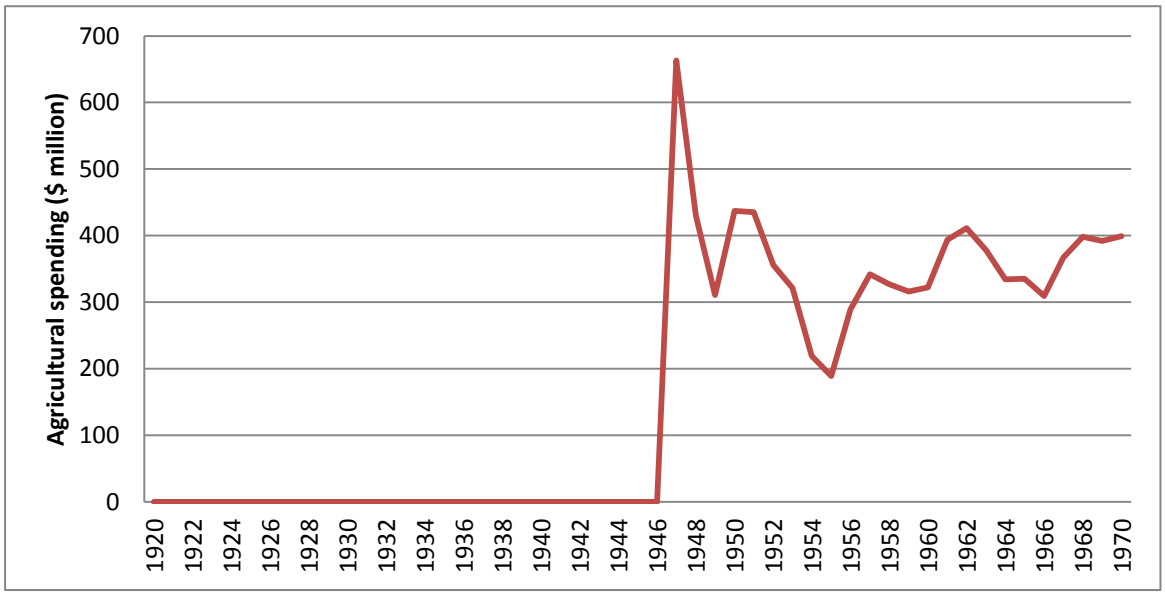

Figure 11: UK public spending on agriculture, 1910-1970 (data from Chantrill, 2016)[4].

Effects of policy on system: Wartime policies had technical and infrastructural consequences, which locked-in the new regime. Farmers, supported by subsidies and guaranteed prices, and at times directly coerced through the actions of War Agricultural Executive Committees, made greater use of machinery, fertilisers and pesticides, invested in drainage, and increased the amount of land under cultivation (Grigg, 1989; Wilt, 2001). The use of machinery had transformative knock-on effects: their large demands for space required the simplification of farm layouts, while the costs of implements further favoured specialisation; both of which made mixed agriculture less viable. This, in turn, increased the importance of fertiliser and pesticides (Whetham, 1970).

After the war, farming increasingly evolved into 'agri-business', with primary farmers becoming embedded in lengthening supply and distribution chains based on a modernised, input-dependent model of agriculture. Institutional arrangements became an 'iron triangle', in which politicians, civil servants at the Ministry of Agriculture, and farming organisations (especially the NFU) shared the same goals of increased production and continued price security, and cooperated closely to implement these goals in policy decisions. Farmers, meanwhile, found themselves on a "chemical treadmill" (Smith 1993), in which the use of fertilisers and pesticides necessitated further, increasing use of chemicals. Thousands of smaller farms went out of business during this transition, as they could not compete with larger, mechanized farms (Figure 12). These 'losers' had limited access to policymakers, because the NFU, which sided with larger farms, actively excluded other interests from the new institutional arrangements (Cox et al., 1986). Government technical advice also played a role in cementing this change, mainly through the National Agricultural Advice Service, established in 1946 to provide technical advice to farmers based on a technological paradigm emphasising specialised, input-intensive agriculture (Grigg, 1989).

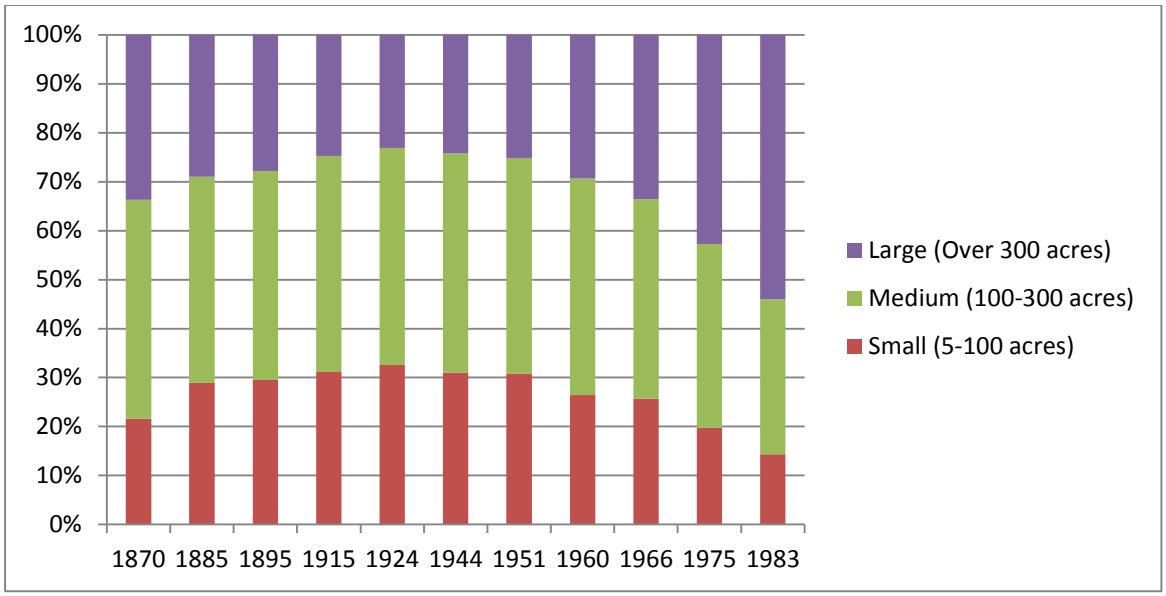

Figure 12: The changing distribution of farm holdings in the United Kingdom, 1870-1983 (data from Grigg, 1987)

[4] The apparent lack of spending between 1920 and 1947 is likely due to changes in budgetary categories, rather than a complete lack of spending.

6. Analysis

Both case studies show that socio-technical transitions *can* be accelerated by policymakers, whose interventions moved niche-innovations across the tipping point. Decisive policy instruments included large-scale public infrastructure investments, guaranteed markets with attractive fixed prices, substantial investment grants, and enhanced knowledge dissemination (via demonstration farms, extension services, workshops, brochures). The cases also showed that the decisive policy instruments were introduced in particular *conditions*, which we analyse further below at different levels of granularity.

6.1. MLP-related conditions

Using the three MLP-levels described in section 2.1, we develop a first, coarse-grained understanding of conditions of major policy change in both cases.

- In the transport transition, the crucial conditions entailed both increasing momentum of the niche-innovation (road transport) and a weakening socio-technical regime (railways), which stimulated policymakers to defect from the latter to the former. Landscape developments played a moderating role (World War II damaged the railways; in the 1950s, economic growth provided the government with more resources and rising wages enabled consumers to buy cars).
- In the wheat agriculture transition, the crucial condition was sudden landscape pressure (World War II), which disrupted the socio-technical regime. Niche-innovations (tractors, combines, land drainage, fertilizers, pesticides) had low momentum and did not exert direct pressure for change. Nevertheless, their presence, and the fact that learning processes had led to some degree of stabilization, enabled policy defection by providing opportunities that policymakers could reorient towards.

These two clusters of conditions clearly demonstrate the two ideal-type patterns of major policy change (crisis-driven and coalition-driven). Both cases also confirm the proposition from section 2.1 that socio-technical regime destabilisation is an important condition for major policy change and defection. This finding suggests that the current literature on the political acceleration of sustainability transitions (which focuses on niche-related alliances, narratives and technological change) should be complemented with deeper analysis of regime stability and destabilisation.

6.2. External pressures and policy regimes

Using the conceptual repertoire of historical institutionalism (described in section 2.2 and linked to the MLP in section 2.3), we develop a more fine-grained understanding of conditions of major policy change in both cases. Assuming that policymakers are locked-in by policy regimes, our framework identified two crucial conditions for major policy change:

1. External pressures from firms, mass publics, and technology (including both artefacts and knowledge/expertise) at the MLP's niche and regime level.
2. Weakening policy regime elements, particularly changes in ideas (e.g. problems definitions, hierarchy of goals) and institutional arrangements.

In the transport case, the balance of *external pressures* from the railway regime and motor transport niche decisively shifted in the 1950s, creating the conditions for major policy change. The summary in table 1 shows that railway regime pressures to maintain the policy status quo were weak on all three dimensions: the railway network needed repair; railway interests were not well-organized and needed financial support (which reduced their political influence); and mass publics had little sympathy for the railways. Meanwhile, pressures for

major policy change from the road transport niche were growing stronger: price/performance improvements improved their appeal with consumers, who increasingly switched to cars, which, in turn, created functional road problems like congestion; road transport industries developed an effective lobby; and mass publics were enthralled with cars.

	Stabilizing pressures from railway regime to maintain the policy status quo	**Pressures for major policy change from road transport niche**
Technology and infrastructure	**Weak.** War damage had badly undermined the functionality of the railway network, requiring expensive repairs. Locomotives also needed upgrading (to diesel and electric).	**Moderate.** Technological improvements made motor vehicles more competitive, but the lack of a good road infrastructure created congestion problems and was blamed for accidents.
Firms and interest groups	**Weak.** The railway's economic problems reduced their political clout. Their continued reliance on public support increasingly frustrated policymakers. Various railway interests were not organized in an effective lobby.	**Strong.** Expanding road transport industries (buses, trucks, car manufacturers), which generated jobs and exports, developed a powerful road lobby.
Mass publics	**Weak.** Travellers were frustrated with the railways and looking for alternatives. Public discourse condemned monopolistic behaviour and problems with prices and service quality.	**Strong.** Travellers were increasingly turning towards buses, and buying more cars. There were positive discourses associating road transport with modernity, progress, economic growth, and freedom. There were complaints that UK roads were falling behind internationally. Road transport became part of election campaigns. The idea that there were 'votes in roads' was an important motivator for decisive policy action.

Table 1: Summary of pressures on policymakers by railway regime and road transport niche at the tipping point between formative and acceleration phase

This changing balance of pressures was accompanied by a weakening of policy regimes, which created more proximate conditions for major policy change.

- In terms of general orientation, the pre-war *policy paradigm* of 'dealing with externalities' (speed, safety, rural blight, piecemeal road expansion) gave way to a more interventionist post-war paradigm. In terms of specific problem definitions and goals, the railways were increasingly seen as old-fashioned, Victorian, and in continuous need of financial support. The pre-war notion that railways fulfilled a social function was increasingly replaced by a desire for "commercial railways" (Dudley and Richardson, 2000:47) operating without subsidies. Policymakers initially tried to achieve this goal through modernization, but implementation failures set the stage for the new idea of achieving financial viability through cost-cutting costs and scaling-back the railways. For road transport, the general vision of motorway building was welcomed by the late 1940s. But implementation took much longer, because policymakers hesitated to spend large

sums of money. It was not until the late 1950s, when politicians came to think that there were 'votes in roads' that they embarked on comprehensive motorway construction. Cognitive changes (and increasing frustration) thus created endogenous conditions for both major policy changes and the political reorientation from rail to road.

- Changing *institutional arrangements* also created conditions for major policy change. The road lobby initially developed good working relationships with the Ministry of Transport at the level of engineering expertise. By the mid-1950s they became members of the institutional arrangements, helping to develop motorway plans and specific designs. Railway interests, in contrast, were less well organized and became increasingly side-lined, especially after nationalization. The changing influence of road and rail interests thus formed another endogenous condition for major policy change.

In the agriculture case, *external pressures* from the mixed farming regime and specialized wheat farming niche were both relatively weak. The summary of pressures in table 2 shows that regime actors were discontent with the status quo, but too weak and eroded to exert much pressure. Niche-related pressures on policymakers were also limited, because technologies had limited momentum and few farmers had adopted the new business models. So, major policy change in this case was not related to changes in the balance of pressures, but to an external, disruptive landscape shock (World War II).

	Stabilizing pressures from mixed farming and grain import regime to maintain the policy status quo	**Pressures for major policy change from specialized wheat farming niche**
Technology and infrastructure	**Weak.** Food imports were fatally undermined by World War II.	**Weak.** Tractors, combines, fertilizers and pesticides were limitedly used and diffused slowly.
Firms and interest groups	**Weak.** The domestic agricultural regime was starved of investment and in a commercial crisis, so there was unhappiness about the status quo. Agricultural interests mobilized for policy change, but were initially over-ruled by industrial and trade interests.	**Weak.** British farmers had few opportunities to innovate and showed limited interest in new business models based on specialisation and technological inputs.
Mass publics	**Weak.** Consumers were not showing dissatisfaction with existing agricultural systems. But there were popular concerns about the countryside, which created some demand for government intervention.	**Moderate.** There was some enthusiasm for efficient, "modern" methods, but also concerns about "prairie farming".

Table 2: Summary of pressures on policymakers by mixed farming and import regime and road specialized wheat farming niche at the tipping point between formative and acceleration phase

The external shock (World War II) disrupted the policy regime, creating further policy and political changes.

- Problem definitions and goals shifted rapidly from a free-trade *policy paradigm* to a highly interventionist paradigm with new goals that were maintained after the war (increased food production, cheap food consumption, financial stability for farmers).
- In terms of *institutional arrangements*, farmer's interests (particularly the NFU) gained policy access in the late 1930s, which enabled them to shape the policy instruments that were implemented when war broke out. This contradicts the proposition from section 2.3 that the enrolment of societal groups *follows* the implementation of new policies in the crisis-driven pattern. So, even with this major shock, policymakers consulted with interest groups (although one could also argue that the threat of war was seriously discussed since 1938, thus providing time for consultation). After the war, the institutional arrangements morphed into closed policy networks, which locked in the new policy regime.

6.3. Policy feedbacks over time

Conditions for major policy change are not static or exogenous, but can arise over time and are partly shaped by policy feedbacks. Below we explain for both cases how these policy feedbacks played out across our three external pressures (business interests, mass publics, technology) and how these temporal dynamics created the conditions for major policy change, discussed above.

For the transport case, Table 3 summarizes the main mechanisms in two rounds of policy feedback: from initial conditions to policies, which had feedbacks on the system, which created the conditions for major policy change, which then had feedbacks that locked in the new system and policy regime. The initial conditions, at T0, included an emerging car industry and struggling and damaged railway industry, but also a reputation for railway monopolism, so the first round of policy changes (T1) were designed mainly to promote efficient railway operation while curbing monopolism and giving tentative support to road transport. This created feedback effects as the road transport system grew more powerful relative to the railroads, enjoying increased support from business lobbies, travellers, and technological experts. This in turn created the conditions for another set of policy changes (T2), which deliberately accelerated the transition to road transport, leading to lock-in through a more empowered road lobby, changed user habits, a durable road infrastructure advocated by technical experts, and the corresponding collapse of railway businesses, travel practices, and infrastructure.

	Business	Mass publics	Technology
T0: End of First World War			
Initial Conditions	Emerging car industry, pushing against rail nationalisation Struggling railway industry and weak rail lobby.	Emerging class of motorists, who allied with road transport business. Public frustration with the railways	Damaged railways. Insufficient infrastructure for road-based transport system, but cheaper vehicles than before the war.
T1: Interwar developments and post-war decade			
Policies	**Ideas:** Assumption that railways would remain a monopoly; preference for unified railway control. **Institutional arrangements:** Ministry of Transport, with a road-building department. **Policies:** Regulation, but not nationalisation, of the railways.		
Feedbacks (creating conditions for major policy change)	Road transport's commercial advantage over the railways.	Traveller preference for buses and eventually private cars. Continued frustration with the railways.	Gradual development of trunk roads, but with teething problems. Damaged and increasingly outdated railways.
T2: Developments in the late 1950s and thereafter			
Policies	**Ideas:** Assumption that the solution to transport problems was to build more roads; Desire for a financially self-sustaining railway system. **Institutional arrangements:** Creation of the BTC; later British Rail. Establishment of road interests as a key group to consult on transport policy. **Policies:** Motorway construction; Railway modernisation; Railway cuts		
Feedbacks (that lock-in new system and policy regime)	Increasingly prosperous and politically powerful road transport industry. Declining nationalised railway system, eventually dependent on subsidies.	Public expectation of convenient, congestion free roads. The decline of railways meant that many travellers had no choice but to travel by road.	Rapid expansion of road system, and contraction of the railways system. Technical experts viewing road construction as the natural solution to transport problems.

Table 3: Summary of policy feedback mechanisms in the transport case study, showing how developments among business, mass publics, and technology fed into policies which had further knock-on effects on those three dimensions

For the agricultural case, Table 4 summarizes the main mechanisms in two rounds of policy feedback. The initial conditions (T0) saw the agricultural system under severe pressure from low-cost imports, leading to an agricultural depression. Early policy efforts (T1) offered modest relief, but made little progress, demonstrating how the import-dependent system was locked in due to technical challenges, business lobbying, and internal policy commitments. Their feedbacks, however, included increased involvement of farming organisations in the

policy process as well as more experimentation with modern agriculture, which provided the preconditions for dramatic policy change (T2) when the status quo was radically disrupted by the Second World War. This policy change, in turn, caused business and technical lock-in which cemented the system of modern agriculture.

This pattern suggests that political lock-in can make niche actors' efforts futile, but also that this lock-in is vulnerable to landscape disruption. This should be qualified, however, because the policy feedback effects during the agricultural depression did galvanize the mobilization of the agricultural lobby and stimulated learning processes around specialised modern agriculture. Without these feedbacks, it is not clear that the government would subsequently have chosen the policies it did in order to respond to the threat of a wartime food crisis.

	Business	Mass publics	Technology
T0: Interwar agricultural depression			
Initial Conditions	Farmers under severe pressure from imports. No money for investment. Many farms abandoned and left to go fallow. Farmers' advocacy groups began to pressure the government.	Mostly imported grains used for bread baking. Public concern about the state of the countryside.	Agricultural practices and technologies based around a traditional mixed farming system. Some limited experimentation with chemicals and machinery, but many practical problems.
T1: Run-up to the Second World War			
Policies (creating conditions for major policy change)	**Ideas:** International trade concerns were deemed more important than transformative support for domestic agriculture **Institutional arrangements:** Gradual development of ties between Ministry, NFU, and other groups. **Policies:** Modest relief for grain farmers, but no reduction in imports.		
Feedbacks	Involvement of farming organisations (operating behind a united front led by the NFU) in planning for wartime food policy. Proactive efforts from farming sector to influence post-war food policy.	Demand for food during wartime.	Anticipated failure of the import system predicted in the event of war. Constraints on options for expanding domestic production (horse rearing times, etc.)
T2: Wartime and post-war			
Policies	**Ideas:** Price guarantees and production increase as the preferred way to deal with wartime food constraints. **Institutional arrangements:** Direct involvement of NFU and allied organisations in war county agricultural committees. **Policies:** Price support, technical advice, drainage grants, leasing of equipment. Continued after war.		
Feedbacks (that lock-in new system and policy regime)	Prosperity for farmers, enabling investment. Growth of farm supply industries. Entrenchment of NFU in policy apparatus. Concentration of the industry in a smaller number of larger farms.	Insulation of process from public influence.	Rearrangement of farms to facilitate use of machinery; removal of livestock and additional crops. "Chemical treadmill"

Table 4: Summary of policy feedback mechanisms in the agricultural case study, showing how developments among business, mass publics, and technology fed into policies which had further knock-on effects on those three dimensions

6.4. Conditions for political acceleration of transitions

Despite case-specific differences, we observe several similarities in the conditions that enabled political acceleration of the transition. These refer both to *external* pressures from our three analytical categories (businesses, mass publics, and technology) and to developments *internal* to the policy process, as illustrated in Table 5.

Business interests	**Mass publics**	**Technology**
-United niche front -Weakening regime lobby	-Voter support for change -User groundswell -Popular discourses	-Technical improvements -Expert endorsement
Policy-internal developments - Policy ideas (problem definitions, goals) - Institutional arrangements -High-level (ministerial) support -Frustration with incumbents		

Table 5: Summary of the conditions for the political acceleration of socio-technical transitions

On the business side, one common point is a united front among niche advocates (coherent motor lobby; agricultural organisations rallying behind the NFU), which was a critical driver of change in both cases, allowing supporters of the niche technology to more effectively influence policy. Another important point in business is the weakening of the incumbent regime's lobby (declining railways; declining diplomatic importance of grain exporters), which created an opening for niche actors to exploit. Among wider publics, voter support for change, coming from a groundswell of new user demands (increased car use, wartime food requirements), played a role in both cases, although less prominently in the agriculture case. Popular discourses (enthusiasm for motorways; concern about the state of the countryside) also played a role among mass publics in both cases, although most prominently in the transport case. With regard to technology, price/performance improvements were important drivers (cheaper cars; new road designs, more efficient tractors and chemical inputs), as well as expert endorsement, which appeared when experts (road builders; agricultural scientists) created a body of expertise that normalised certain policy solutions.

For policy-internal conditions, we first notice the early importance of policy *ideas* such as the notion that transport problems should be addressed by building roads, or that agricultural production could be expanded through government support. Secondly, in each case, these ideas were further empowered by frustrations with incumbents (railway underperformance; agricultural depression). Thirdly, changes in *institutional arrangements* were important to create conditions for major policy change, particularly increased policy access for niche advocates (road lobby, NFU). Finally, we observe the importance of high-level support, most commonly in the form of sympathetic ministers, who were sometimes directly involved with ascendant niche industry (e.g. Marples owned a majority stake in a road-building firm; Dorman-Smith was former president of the NFU). Such high-level Ministerial support is important to advocate major policy changes within Cabinet, often in the teeth of opposition from other government departments such as the Treasury.

The common pattern across both cases leads us to propose that these conditions are the crucial enablers of deliberately accelerated transitions.

7. Conclusion

This article has attempted to contribute to the debate on political acceleration of low-carbon transitions, focusing particularly on the conditions for major policy changes that tilt regulatory frameworks or commit large-scale resources. To go beyond technocratic analysis *of* policy and normative appeals to 'political will', we mobilized insights from historical institutionalism and linked these to the Multi-Level Perspective to make them relevant for socio-technical transitions. We proposed two temporal patterns by which the political acceleration of transitions can occur and identified the conditions for major policy change, which include both external pressures from business (united niche lobby fronts and weakening regime lobbies), mass publics (voter support, new user demands, popular discourses), technology (price/performance improvements and expert endorsement) as well as policy-internal developments (changing problem definitions and goals, high-level Ministerial support, altered access to institutional arrangements, and frustrations with incumbents). We confronted our conceptual framework with two historical case studies which confirmed its analytical utility and also demonstrated that conditions for policy change are not static or entirely exogenous, but are partly shaped by policy feedbacks over time.

An important limitation of our empirical approach is the role of context, as we relied on two case historical studies, taking place within a single national and temporal context. This carries the risk that there were specific dynamics at work in mid-20th century Britain (e.g. modernist enthusiasm for technology, wartime contingencies, acceptance of large-scale government intervention) that are not at work today, in the context of global climate change policy. We have also not fully investigated the role of policy-internal processes, because our choice for historical institutionalism has conceptual limitations (e.g. focus on context, temporality, and broad political struggles). Other theoretical approaches (e.g. advocacy coalitions, multiple streams, policy networks, policy learning) may help address this limitation in future work.

Returning to the initial motivation, we end the paper with speculations about political acceleration of low-carbon transitions. On the negative side, the identified conditions for major policy change appear under-developed, which complicates deliberate and decisive acceleration, despite some progress in some areas. While some low-carbon industries (solar-PV, wind) have grown in some countries, they do not yet present a strong united lobbying front, while fossil fuel lobbies remain strong. Among mass publics, there are popular discourses about fighting climate change, but voter support for an accelerated transition is tentative at best, and new user demands related to technologies such as electric vehicles and renewable energy are only beginning to emerge. Price/performance improvements are strong drivers for some technologies (especially solar-PV, wind, battery-electric vehicles), but many other low-carbon innovations (e.g. heat pumps, whole-house retrofit, district heating) are still relatively expensive or unfamiliar to the wider public. Some expert communities are also pushing back publicly against alternatives, for instance in the technical controversy over base-load power and renewables. Finally, for policy-internal developments, many proposals remain framed in neo-liberal terms, suggesting that a policy paradigm shift (e.g. towards greater interventionism) has not yet occurred. Although climate and environment policymakers often convey ambitious statements and sometimes have agreed on targets (e.g. in the 2015 Paris agreements), their concrete translation into sectoral policies (transport, energy, housing, food) is slow and not yet decisive. In many jurisdictions, high-level Ministerial support for low-carbon transitions is limited, with frustrations with incumbents occurring only in a few sectors, such as with coal and diesel vehicles where some countries have articulated strong phase-out policies. One important caveat comes from the agricultural

case study, which shows that a dramatic crisis can mitigate against the need for some of these conditions. Climate change, however, does not (yet) present an immediate and existential crisis comparable to the one facing British food supply during the Second World War.

Our findings are not entirely pessimistic, however. They also highlight the importance of policy feedbacks in gradually creating the conditions for major policy change. This means that deliberate acceleration does not have to wait until the conditions we have outlined appear from exogenous sources. Instead, policymakers and those trying to lobby for more aggressive climate policy can work to build alliances, create and communicate consensus policy solutions to be implemented when the time is ripe, and push for institutional changes which will increase the political power of those supporting low-carbon solutions. These may help create more of the conditions we have outlined, thereby facilitating more decisive policy action in the future.

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