Can we afford to be more like Scandinavians?
institutions, incentives and innovation in the global political economy

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Abstract

It has recently been suggested that "we cannot all be like the Scandinavians" because "cuddly" social democratic countries free-ride on innovation spillovers from "cut-throat" liberal countries (Acemoglu et al. 2017: 1284). This "asymmetric growth" thesis stands in contrast to other theories regarding the institutional determinants of innovation, including varieties of capitalism and beneficial constraints theory, both of which contend that non-market coordination can facilitate innovation. Multi-method analysis of pharmaceutical patents filed with the United States Patent and Trademark Office (USPTO) finds only weak support for the claim that liberal institutions are necessary for radical innovation. Although most influential patents originate in liberal countries, social democratic countries contribute in non-trivial ways to the global stock of knowledge. These findings are robust across fuzzy-set, structural equation and network-analytic models, using both citation-based and text-based measures of innovation. Case analysis of an influential Swiss patent reveals that high-powered incentives were but one, seemingly minor, factor for success. Low-powered incentives, public goods and norms also mattered. The evidence indicates that, while it may be true that the pace of technological progress would not be sustained if every country adopted Scandinavian-style institutions, little would be sacrificed in becoming more like the Swiss.

Keywords: asymmetric growth, beneficial constraints, innovation, multi-method analysis, patents, varieties of capitalism

JEL classification: D02, L50, O31

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1 Introduction

Sustained and increasing economic inequality has given rise to progressively stronger demands for greater redistribution (Koos & Sachweh 2019; Piketty 2014). Although many economists recommend active policy measures to reduce levels of inequality, dissenting opinions abound.[1] In the political economy literature, the asymmetric growth thesis has recently been developed by Daron Acemoglu, James Robinson and Thierry Verdier, which posits that "cut-throat" institutions germane to liberal, American-style capitalism foster high-powered incentives necessary to push the global technology frontier (2012; 2017). From the asymmetric growth perspective, "we cannot all be like the Scandinavians" because economic actors in countries characterized by "cuddly" institutions that proffer ample social protection are incentivized to free-ride on knowledge spillovers from "cut-throat" countries (Acemoglu et al. 2017: 1284).

Notwithstanding its analytical rigor, asymmetric growth theory stands in contrast to much of the received wisdom from the literature on strategic management and comparative capitalism. Indeed, a great deal of research has found that cooperative (non-market) institutions facilitate innovation by reducing transaction costs, fostering network complementarities and otherwise operating as beneficial constraints (Milgrom & Roberts 1995; Streeck 1997; Teece 2009; Witt & Jackson 2016; see also Amable 2003; Block & Keller 2011; Breznitz 2007; Jones & Bachelor 1993; Martin & Swank 2012; Ornston 2012, Taylor 2016; Nelson 1993; Whitley 2007). Moreover, although varieties of capitalism theory is partially consistent with asymmetric growth insofar as liberal economies' propensity toward radical innovation is concerned, varieties of capitalism is more nuanced in that it considers expertise at incremental innovation to be the province of coordinated economies (P. Hall & Soskice 2001: 39; Soskice 1997: 75).

Despite much debate and theoretical abundance, robust empirical evidence on the institutional determinants of innovation is scant (Witt & Jackson 2016). This paper contributes to scholarship on the matter by analyzing both text-based and citation-based indicators of innovation using an original dataset that contains the text and metadata of 55,255 pharmaceutical patents filed with the United States Patent and Trademark Office (USPTO) between 1965 and 2021. Whereas most previous research has relied on patent citations to measure innovation, text analytic methods are arguably required to overcome

[1] Conventional arguments against redistribution have hinged on erosive effects on incentives (Rebelo 1991). Recently, attention has been drawn to political economy arguments (and evidence) against the Kuznets thesis (that industrialization will coincide with greater equality), which has prompted considerable debate about the natural tendencies of capitalism (Delsol et al. 2017; Piketty 2014). Others have argued that discussion of natural tendencies is moot, given that distribution in society is profoundly affected by institutions (Acemoglu & Robinson 2015; Hacker & Pierson 2010). Consensus nevertheless appears to be shifting in favour of greater redistribution, as estimated economic benefits greatly outweigh costs (Berg et al. 2018). Indeed, from the endogenous growth perspective, "a high degree of inequality between rich and poor individuals may encourage the poor to expropriate the rich at the expense of aggregate investment and growth" (Aghion & Howitt 1998: 292-93; see also Bénabou 1996). Expropriation can, however, be welfare-enhancing, even if not growth-enhancing (Sen 2017). See Nielsen (2018) for a recent review of the literature that straddles the nexus between the normative and technical dimensions of the inequality question.

problems of biased estimation recently identified in the literature on patent citations (Kuhn et al. 2019).

Although innovation in many industries may not be adequately captured by patent data, pharmaceuticals are well-suited to patent-based measures for two reasons. First, commercial advantage in pharmaceuticals often goes to winners of patent races (Sussex & Marchant 1999). Second, it is generally safe to assume that firms to which patents are assigned proceed to commercialize innovations contained in patents, either by obtaining financing to develop drugs, by licensing intellectual property to firms with capacity for commercialization, or via partnerships, mergers or acquisitions (Sternitzke 2010). Pharmaceutical patents thus provide a solid empirical foundation from which to derive inferences about the institutional determinants of innovation advantage.

The paper proceeds as follows. Section 2 reviews prior literature on the institutional determinants of innovation. Section 3 assesses the degree to which institutional covariates predict innovation using a mixed method approach that combines a case study with fuzzy-set analysis, structural equation modelling and network analytic techniques. Section 4 outlines possibilities for theoretical synthesis in light of findings that suggest asymmetric growth, varieties of capitalism and beneficial constraints theory may all be partly correct. Section 5 summarizes the main points of the study and directions for further research.

Although the findings are in line with the contention that liberal institutions are most conducive to radical innovation, liberal institutions cannot be considered strictly necessary for radical innovation. Rather, countries characterized by non-market institutions have their fair share of influential patents. Yet, insofar as institutional configuration corresponds with radical innovation, fuzzy-set analysis identifies only liberal configurations. Network-analytic methods also find somewhat greater incidence of knowledge diffusion from liberal to coordinated countries than vice versa. However, case analysis of an influential Swiss patent reveals that high-powered incentives (i.e., remuneration based on performance) were but one, relatively minor, contributor to successful innovation. Other factors included norms (i.e., sense of duty), public goods (i.e., university laboratories) and low-powered incentives that shielded the inventor from risk (i.e., remuneration independent of performance).

Thus, although there is some indication that the pace of technological progress would not be sustained if all countries were to adopt Scandinavian-style institutions, social protection does not completely undermine incentives toward radical innovation. The challenge for social planners and managers is to devise institutions that exploit economies associated with low-powered incentives while avoiding moral hazard. Insofar as an answer can be provided to the question posed in the title, while it may be true that we cannot all be like the Scandinavians and maintain the current pace of technological progress, we all may be able to be more like the Swiss.

2 Innovation, institutions and economic advantage

Mainstream social science defines institutions as rules that constrain and enable behaviour by structuring incentives (North 1990). Although institutions may encourage positive sum solutions to social problems, there is no guarantee institutions will be either efficient or welfare-maximizing (Acemoglu 2001; Axelrod 1984; Miller 1992). This realization has given rise to a voluminous literature on institutions and innovation.

While an exhaustive survey of the literature is impossible in a single essay, three general themes pertinent to the task at hand may be discerned. One theme, prevalent in the literature on asymmetric growth, centres on the relationship between market incentives and innovation (Acemoglu et al. 2017). A second theme, central to the varieties of capitalism thesis, focuses on the relationship between market-based institutions and radical innovation, on one hand, and non-market institutions and incremental innovation, on the other (P. Hall & Soskice 2001). The third theme, characteristic of much of the remaining literature on comparative capitalism and strategic management, emphasizes the different ways various institutional combinations can affect innovation by acting as beneficial constraints on pathological base tendencies associated with governance that relies excessively on either markets or non-market institutions (Streeck 1997; cf. Polanyi 1944). Although the term "beneficial constraints" is used sparingly in the literature, many studies that exalt governance by "neither states nor markets" fit the third category (see, for example, Amable 2003; Blyth 2002; Boyer 2004; D. Breznitz 2007; Crouch 2005; Evans 1995; Gereffi et al. 2005; Hira 2007; Lundvall 1992; Ornston 2018; Porter 1990; Taylor 2016; Whitley 2007; Zysman 1983).

Starting with the asymmetric growth thesis, the crux of the argument is that an incentive-insurance trade-off begets an "asymmetric world equilibrium" (Acemoglu et al. 2017; cf. Hölmstrom 1979). Specifically, social planners at the national level are assumed to opt for either high ("cuddly") or low ("cut-throat") levels of social protection based on strategies pursued by other planners in the global system, a stylized representation of which is given in Figure 1.

Figure 1: Countries classified by level of social protection

Based on the "overall generosity" index from Brady et al. (2020) and wage bargaining measures from Visser (2019).

Acemoglu, Robinson and Verdier demonstrate that, in all conceivable games, the lowest aggregate payoff is obtained when every country opts for "cuddly capitalism" (2017: 1248). Moreover, countries with established institutions of social protection (and strong social democratic parties dedicated to their preservation) are considered to have made ex ante commitments to cuddly strategies. Thus, as discussed below in the context of microfoundations, although institutions in liberal countries tend to bestow social planners freedom of choice over policy, commitments of social planners in coordinated economies to "cuddly capitalism" render cut-throat strategies the optimal choice for social planners in liberal countries.

Of course, institutions are liable to change if social planners select alternative strategies in subsequent iterations of the game. Indeed, Acemoglu, Robinson and Verdier argue that the development strategies of Taiwan and South Korea involved switching from cut-throat to cuddly institutions over time (2017: 1270). Although asymmetric growth theorists have interesting things to say about mixed strategies that involve switching between or otherwise combining different types of institutions, the bottom line is that at least one country must adopt cut-throat institutions and assume the role of technological leader lest the system grind to a halt.

Despite sharing some basic premises, the varieties of capitalism thesis leads to starkly different conclusions than asymmetric growth theory. As in asymmetric growth theory, high-powered incentives characteristic of market-based institutions are expected to yield radical innovation, which is considered to entail "substantial shifts in product lines, the development of entirely new goods, or major changes to the production process"; however, low-powered incentives characteristic of non-market institutions are thought to coincide with comparative advantage in incremental innovation, which is considered to be "marked by continuous but small-scale improvements to existing product lines and production processes" (P. Hall & Soskice 2001: 37-39).

As elaborated in greater detail below in the discussion of microfoundations, the intuition behind the varieties of capitalism thesis is that high-powered incentives encourage risk-taking conducive to radical innovation. Meanwhile, non-market institutions require economic actors to coordinate their behaviour over repeated rounds of bargaining and compromise. In time, coordination is hypothesized to create network complementarities necessary for successful incremental innovation (Soskice 1997; cf. Milgrom & Roberts 1995; Teece et al. 1997).

On the preceding point, it would be inaccurate to claim that asymmetric growth theorists are ignorant of the potential relationship between non-market institutions and incremental innovation. Rather, asymmetric growth theorists do not consider incremental innovation to be particularly valuable insofar as the advance of the global technology frontier is concerned. As put by Acemoglu, Akcigit and Celik "though incremental innovations also increase productivity, it is the radical innovations that are the engine of growth… because incremental innovations in a particular technology cluster run into diminishing returns" (2020: 2). Varieties of capitalism theorists, by contrast, consider incremental innovation to be a viable growth strategy, especially when institutional complementarities are great. In that respect, varieties of capitalism theorists share common ground with John Kenneth Galbraith who, drawing on examples from the auto industry, juxtaposed the ease with which early producers could commercialize radical innovations against the high level of planning and coordination required to produce incremental innovations in the same industry decades later (Galbraith 1972: 55-64).

Although varieties of capitalism theorists have always taken care to emphasize that no country perfectly fits either the ideal "liberal market economy" (LME) or the ideal "coordinated market economy" (CME), they do argue that the United States and Germany come close. This characterization has been challenged, however, on the basis that German and other coordinated countries' institutions have undergone reform over time (Schneider & Paunescu 2012; Thelen 2014). To accommodate and rebuff criticism of the dichotomous, ideal-typical orientation of varieties of capitalism, the approach has since been recast using continuous indices to measure the breadth and depth of coordinative institutions (P. Hall & Gingerich 2009; see also Kogut & Ragin 2006). Accordingly, the latest research employs several indices to capture features of the institutional milieu, which are used to assess institutional effects on the capacity for innovation and associated economic advantages (Schneider et al. 2010; Witt et al. 2018). This shift toward an index orientation has brought varieties of capitalism closer to other perspectives under the ambit of comparative capitalism, most of which implicitly or explicitly emphasize the benefits of institutional constraints on self-serving behaviour (Witt & Jackson 2016).

For the most part, detractors of asymmetric growth and varieties of capitalism take exception to the simplicity of theories that rely heavily on ideal types, preferring instead to focus on the implications of "institutional diversity" (Aoki 2000; Crouch 2005; Jessop 2011; see also Ostrom 2005). In this spirit, Wolfgang Streeck coined the term "beneficial constraints" to convey economic benefits associated with institutional checks on "rational voluntarism" —that is, institutions which have the effect of "constraining actors' preferences, employing governance to bar them from doing what they would want to do, and making them do what they would not want to do on their own" (1997: 198). A major rationale for the implementation of beneficial constraints stems from the fact that negative externalities and other market failures have deleterious economic consequences for society (cf. Polanyi 1944; Tullock 2005). Although market failure has been recognized in mainstream economics since Adam Smith, beneficial constraints go beyond minimal regulations necessary for functioning markets to include institutions that facilitate cooperative solutions to collective action problems (Streeck 1997: 199; cf. Axelrod 1984; Evans 1995; Milgrom & Roberts 1995; Ostrom 2005). Per the discussion of microfoundations below, the most consequential of these institutions involve stakeholder representation in decisionmaking bodies and mechanisms that facilitate efficient communication and bargaining.

Beneficial constraints have recently featured in a persuasive reinterpretation of comparative institutional advantage advanced by Michael Witt and Gregory Jackson, which posits that "radical innovation may be based on the 'beneficial constraints' of opposing institutional logics rather than on the self-reinforcing institutional coherence envisioned in much of the Varieties of Capitalism literature" (2016: 778). As mentioned above, opposing institutional logics may be beneficial because purely market-based institutions expose the economy to market failures, whereas non-market institutions are vulnerable to rigidity, moral hazard, opportunism and associated governance failures (Jessop 1998; Le Grand 1991).

A summary of the predictions made by asymmetric growth, varieties of capitalism and beneficial constraints theorists is given in Figure 2. A proper appreciation of the rationales behind these predictions requires consideration of microfoundations. As discussed in the next section, points of contention reflect broader debates in political science and sociology between "inertia" and "collective action" schools of thought, both of which offer plausible accounts of how micro-level behaviour scales up to produce macro-level outcomes.

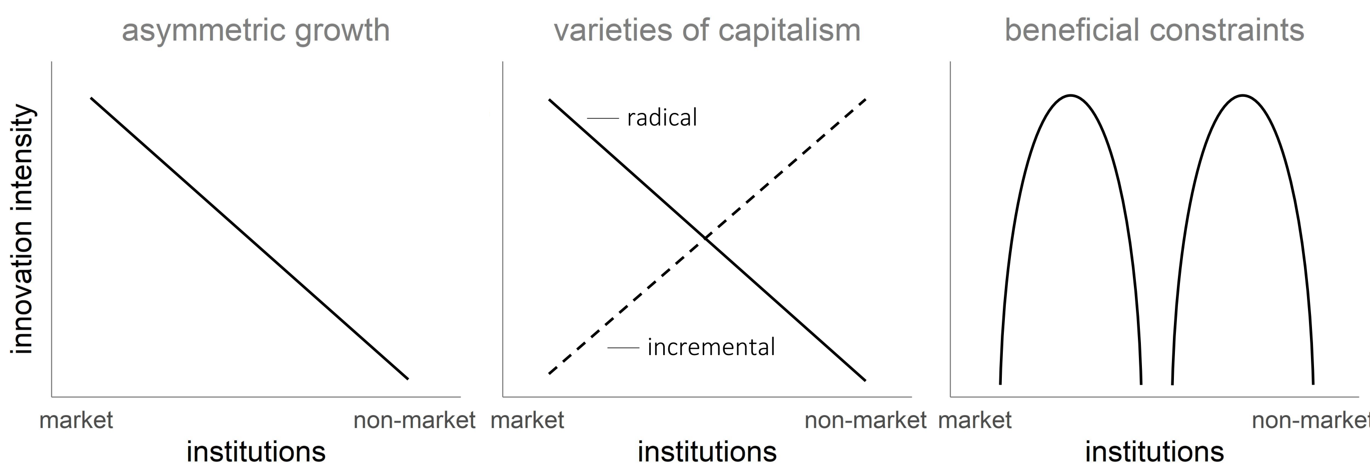

Figure 2: Three theories of innovation

The asymmetric growth thesis contends that liberal countries with disproportionately market-based institutions foster incentives that produce innovations necessary advance the global technology frontier. Varieties of capitalism holds that liberal market economies (LME) characterized by market-based institutions excel at radical innovation while coordinated market economies (CME) characterized by non-market institutions excel at incremental innovation. The beneficial constraints thesis predicts greater incidence of innovation part way toward the centre of the institutional spectrum on both sides, and lesser incidence of innovation in the middle and at the poles.

2.1 Microfoundations: between inertia and collective action

There are two broad schools of thought regarding the effect of institutions on decisionmaking. The "inertia" school anticipates that the number of veto players involved in decisionmaking will be positively associated with status quo bias because, ceteris paribus, agreement to depart from the status quo will be more difficult to obtain when veto players are many than when veto players are few (Shepsle 2010; Tsebelis 2002). In other words, status quo bias is a function of "institutional friction" (Jones & Baumgartner 2005). Inversely, the "collective action" perspective predicts a negative relationship between the number of veto players and status quo bias because opportunities for collective action are greater in large, heterogenous and representative groups (Marwell & Oliver 1993).

Theories of inertia and collective action are pertinent to discussions of innovation because they deal with change and because they apply to groups of all sizes, from small committees to entire societies (Black 1958). Although the two perspectives make opposite empirical predictions, they are based on commensurable theories of human behaviour (Coleman 1990). Moreover, both are intuitively plausible, and both could conceivably be correct depending on the circumstances (see Figure 4 below; Birchfield & Crepaz 1998).

Consider a simple model in which x represents a venture and y represents innovation produced therefrom, so that $x \Rightarrow y$. Canonical social choice theory posits the following:

$$\left(\sum_{i=1}^{n} p_i(y)u_i(y) > 0 \rightarrow x\right) \wedge \left(\sum_{i=1}^{n} p_i(y)u_i(y) \leq 0 \rightarrow \neg x\right), \tag{1}$$

where $p_i(y)$ represents the probability assigned by the i^{th} veto player to the innovation coming to fruition, so that $p_i(y)u_i(y)$ is the expected utility function $\forall\ i \in n$. Venture x is assumed to be forthcoming only when n veto players i expect to marshal sufficient return to compensate $i \in n$ for whom $p_i(y)u_i(y) \leq 0$.

From the inertia perspective, departures from the status quo are more likely to be voted down as the number of veto players increases because the subset of n for which $p_i(y)u_i(y) \leq 0$ is assumed to increase with the addition of decisionmakers (cf. Buchanan & Tullock 1962: 66). Moreover, the risk of the venture affects $p_i(y)$ such that, ceteris paribus, riskier and more radically innovative projects will increasingly be voted down as veto players are added because humans tend to be risk averse (Kahneman & Tversky 1979). Substantively, radical innovation is predicted to transpire more frequently in low friction systems with few veto players, where potential losers from innovation are powerless to resist change.

From the collective action perspective, by contrast, routinized bargaining among many veto players may beget trust-building, cooperation and capital accumulation over repeated games, rendering viable opportunities for collective action that would not exist under less representative institutions (Scharpf 1997). Whereas the production function of x was assumed to be a decreasing function of the number of veto players from the inertia perspective, from the collective action perspective, the production function of x is considered a constant or increasing function of the number of veto players, so that aggregate expected utilities increase (instead of diminish) with the addition of veto players (see Oliver et al. 1985). Substantively, friction, veto players and network density translate to increased economies of scale and scope that complement, facilitate or render viable innovative pursuits.

The preceding discussion suggests that the shape of the production function is determinative; what matters is the extent to which benefits from innovation may spillover and diffuse across society. When innovation instead corresponds with disruption, it is reasonable to expect that radically-innovative ventures will be blocked in high friction systems with broad representation. Formally, aggregate utility is a negative function of n. However, cooperation within dense networks that coincide with representative political systems may yield Pareto optimal responses if potential losers can be accommodated in the process of restructuring —that is, if planners can leverage spillovers to render aggregate utility a positive function of n. Incidentally, dense networks of coordination have been argued to facilitate cooperative, wide-ranging innovation by leveraging network complementarities in order to achieve economies of scale and scope (Milgrom & Roberts 1995; Soskice 1997).

The literature on "embeddedness" attempts to identify network characteristics most conducive to innovation. In this vein, Peter Evans (1995) developed the concept of "embedded autonomy" to convey the delicate balance between state capture by private interests and the state's ability to utilize privately-held resources for society's benefit. Contrary to the "structural determinism" of conventional theories of comparative advantage, the scholarship on embeddedness insists on a more dynamic role for agents to seize, and in some cases create, growth opportunities (Evans 1995: 8-9).

The notion that opportunity is not entirely preordained also features in contemporary discussions of "endogenous growth," "innovation systems" and the "triple helix" of industry-government-university relations (Aghion & Howitt 1998; Etzkowitz & Leydesdorff 1996; Lundvall 1992). At a basic level, it has long been recognized that universities supply knowledge as a public good that would otherwise be undersupplied by markets (Arrow 1962; Nelson 1959). Evidently, the state can affect factor markets for innovation (Phillips 2007). Yet, as discussed later on in the context of the Biogen case study, there are many decisions to be made regarding how universities mesh with industry and societal actors (S. Breznitz 2014).

In an attempt to explain industrialization strategies of Ireland, Israel and Taiwan, Dan Breznitz (2007) examined what might be called "varieties of embeddedness" at the sectoral level, and argued that there are many more paths countries may take than is often assumed in the political economy literature. In particular, networks of public and private actors may be characterized by different levels of public and private leadership as well as different degrees of integration at the local and global levels. Similarly, Mark Zachary Taylor (2016) argued that two important considerations are missing from conventional accounts in political economy: the role of (international) social networks and incentives to break out of sub-optimal trajectories. For instance, in light of the fact that high friction systems tend to stalemate, it is plausible that network actors would strive to find ways to adapt to change so that social costs are minimized while local benefits are maximized, which is an intuitively viable growth strategy (D. Breznitz 2021).

The previous point suggests that actors in high friction, coordinated economies have incentive to pursue well-planned, socially-optimal innovation. However, institutional friction can lead to overreaction and overshooting. Indeed, punctuated equilibrium theorists have found large, arguably excessive, departures from status quo policy in high friction systems (Jones et al. 2009). From a punctuated equilibrium perspective, both inertia and overreaction follow from the inability of high friction systems to respond proportionately to challenges and opportunities as they arise (Jones & Baumgartner 2005). In the innovation literature, Darius Ornston (2018) has documented all three phenomena —inertia, radical change and overshooting— in high friction systems, and attributes radical change and overshooting to the capacity of dense social networks to overcome inertia associated with many veto players.

Although proponents of the collective action perspective appear to be correct that there are ways of breaking free of institutional constraints in high friction systems, acceptable solutions may entail significant transaction costs that raise additional barriers to change (Scharpf & Mohr 1994). By contrast, the possibility space is generally much larger in low friction systems for two reasons. One reason is that dearth of veto players translates to relatively swift decisionmaking with minimal transaction costs (e.g., bargaining costs). The other reason is that opportunities exist to externalize costs onto unrepresented groups. For instance, corporate bankruptcy laws are comparatively lax in liberal countries, permitting insolvent firms to shift the costs of failed ventures on to the public. Likewise, it is much easier to obtain regulatory approval for novel products in liberal countries than it is in coordinated countries, where broad-based representation equates to substantial "precaution" in the regulatory process (Hemphill 2020).

While the number of veto players affecting a particular venture is largely idiosyncratic, country-level estimates have been devised with frictions affecting economic decisionmaking in mind (Henisz 2000). As shown in Figure 3, liberal countries generally feature fewer veto players than coordinated countries. Although the US is often depicted in the opposite light, it has been observed that American institutions are in fact relatively unrepresentative. The brief explanation is that single-member plurality electoral institutions produce a two party system (Duverger's law), which coincides with weak cross-class bargaining and little interest intermediation at the political and sectoral levels (Birchfield & Crepaz 1998; Cawson 1985; Lijphart 2012). Incidentally, business interests tend to dominate American pluralism (Hacker & Pierson 2010; Schattschneider 1960).

Figure 3: Countries classified by number of veto players

Based on the "political constraints" index from Henisz (2017), average values for 1965-2016.

A simplified representation of the processes hypothesized to link institutions to outcomes is shown below in Figure 4. Representative institutions with many veto players exhibit two causal pathways: one characterized by inertia and incremental innovation, and another characterized by collective action and radical innovation. Both pathways are hypothesized to correspond with diffuse benefits because veto players are expected to block ventures that would be costly for society. By contrast, unrepresentative institutions with few veto players exhibit a single causal pathway to radical innovation, which is facilitated by cost diffusion, as there are few veto players to block the imposition of externalities on to unrepresented groups. Because not every venture will be conducive to equitable distribution of costs and benefits, the theory predicts comparatively greater incidence of radical innovation in unrepresentative (liberal) systems, as conveyed by the size of the boxes in Figure 4. However, because cost externalization is kept in check in representative (coordinated) systems, the theory predicts comparatively more equitable growth in those systems (Lijphart 2012: 195-96).

Of course, the binary representation between representative and unrepresentative institutions abstracts to extremes; in the real world, there are gradations between fully representative and fully unrepresentative institutions. These gradations have been associated with different "varieties of dualization" and "growth regimes" that affect diffusion of benefits and the extent to which growth is equitable. For example, Silja Häusermann and Hanna Schwander (2012) found that Continental European countries tend to produce more policy outsiders than Nordic countries.

Whereas asymmetric growth theory pays little heed to collective action arguments, varieties of capitalism and beneficial constraints theory are somewhat amenable. Although varieties of capitalism does not expect radical innovation to flourish in coordinated economies, it does invoke dynamic capabilities and collective action arguments to explain incremental innovation (P. Hall & Soskice 2001: 6). For their part, beneficial constraints proponents argue that "constraints imposed by coordination may be beneficial for markets precisely because they curtail the opportunism and hyper-rationality that lock actors into potential market failures due to collective action problems" (Witt & Jackson 2016: 784).

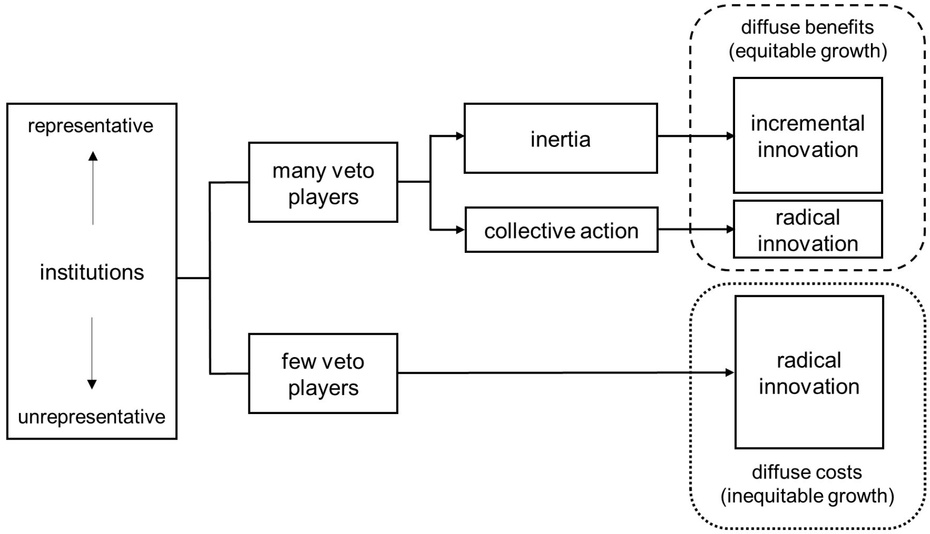

Figure 4: Hypothesized causal pathways to innovation

Box size corresponds with the predicted number of observations in each group. Representative institutions (characterized by many veto players) are hypothesized to generate inertia and incremental innovation in most cases, and collective action and radical innovation in rarer instances where Pareto optimal solutions can be devised. Unrepresentative institutions (characterized by few veto players) are hypothesized to correspond with risk-taking and cost-externalization conducive to radical innovation. Because veto players in representative systems are expected to block ventures that entail externalities, innovation in representative systems is hypothesized to generate diffuse benefits and equitable growth. In non-representative systems, creative destruction and externalities associated with innovation are expected to generate diffuse costs and inequitable growth.

2.2 Prior studies

Although most everyone agrees that institutions profoundly affect innovation, empirical findings on the matter are fragile, at best, and possibly spurious (Jackson & Deeg 2008; Witt & Jackson 2016). Not only have studies that use similar measures thrown up conflicting results, the measures themselves may also be flawed, raising questions about construct validity. This section reviews previous empirical findings on institutions and innovation in light of recent methodological work on the use of patent data in research.

Empirical tests of the asymmetric growth thesis have so far relied on anecdotal evidence from the pharmaceutical industry. Specifically, Acemoglu, Robinson and Verdier argue that "the trade-off between 'the affordability of drugs and technological progress' is widely acknowledged in the pharmaceutical industry... countries at the world technology frontier disproportionately contribute to the incentives for innovation while countries behind the frontier can free ride on these incentives and enjoy 'cuddlier' domestic institutions"; moreover, "there is evidence that policy makers in the United

States and European countries are aware of this discriminatory pricing practice but view it as their best response to preserve it" (2017: 1282).

Whereas the asymmetric growth thesis relies heavily on formal modelling, research on the varieties of capitalism has been empirically-oriented since its genesis. In *An Introduction to Varieties of Capitalism*, Peter Hall and David Soskice used European Patent Office (EPO) data to calculate the degree to which the United States and Germany specialize in technology classes thought to be characterized by radical and incremental innovation, with relative specialization operationalized as the proportion of a country's patents belonging to a technology class minus the proportion of global patents belonging to the same technology class (P. Hall & Soskice 2001: 41). Although Hall and Soskice found support for their thesis, others have argued the evidence to be less clear-cut. For instance, Martin Schneider and Mihai Paunescu found export data to be consistent with the varieties of capitalism theory of comparative advantage, but challenged Hall and Soskice's characterization of liberal and coordinated economies (2012: 739-44; cf. Kenworthy 2006). Conversely, Mark Zachary Taylor accepted varieties of capitalism country classifications but found when regressing National Bureau of Economic Research (NBER) measures of patent "generality" on country type that "LME countries appear at first to be more radically innovative than the CMEs… but not when the United States is excluded from the group of LMEs" (2004: 621).

Yet, several subsequent studies have found partial support for the varieties of capitalism thesis. Based on descriptive statistics of revealed comparative advantage and employment in knowledge-intensive services in a sample of European countries, Matthew Allen and Maria Aldred found that Germany and the United Kingdom rank as predicted across most (but not all) indicators (2009: 590-92). Using USPTO and EPO patent counts and NBER measures as proxies for patent radicality, regression analysis by Dirk Akkermans, Carolina Castaldi and Bart Los found strong support for the varieties of capitalism thesis when using a measure of patent "originality" and mixed, sector-dependent support when either simple patent counts or patent "generality" was used — even when the United States is excluded from the group (2009: 188-89). Employing fuzzy-set analysis, Martin Schneider, Conrad Schulze-Bentrop and Mihai Paunescu found a link between export advantage and two institutional configurations —high incidence of cross-border mergers and a high proportion of university graduates combined with a large stock market— neither of which is affected by the level of employment protection (2010: 259).

More recently, Michael Witt and Gregory Jackson arrived at different conclusions in a fuzzy-set analysis of institutions, patent citation counts, NBER measures of patent radicality and trade performance (2016: 794). Interestingly, Witt and Jackson found trade advantage in radically-innovative industries follows from either of two combinations: highly coordinated employment relations coupled with otherwise market-based institutions, and market-based corporate governance coupled with otherwise non-market institutions. They also found trade advantage in incrementally-innovative industries follows from prevalence of non-market institutions. Incidentally, Witt and Jackson remark that propensity toward radical innovation may be a function of beneficial constraints on purely market-based institutions.

Aside from Witt and Jackson's study, explicit tests of the beneficial constraints thesis have been virtually non-existent. However, implicit findings to its effect characterize a great deal of work in political economy (see Rodrik 2007: 158-61). Bruno Amable has identified numerous ways "the enabling state" regulates the economy, including by "encourage[ing] associational governance and negotiation among private agents in managed capitalism" (2003: 81). Likewise, Robert Boyer noted three "configurations" amenable to success in the current, technology-intensive "growth regime": one based primarily on market regulation, another on dense coordination, and a third conducive to late industrialization that combines market regulation with ample employment protection (Boyer 2004: 15-16; see also Boyer 2005; Martin & Swank 2012; Schmidt 2009).

Several single country studies are also consistent with the beneficial constraints thesis, including those which focus on subnational variation (Haddow 2015). For instance, Marianna Mazzucato's *Entrepreneurial State* traces the many public interventions required to bring Apple's iPhone to market in the United States, and argues that both radical innovation and inequitable distribution followed from the ease with which liberal institutions permit cost externalization —or what Mazzucato terms "socialization of risk" (2013: 202-3). Similarly, Linda Weiss chronicles the relationship between the heavily-subsidized military industrial complex in the United States and marketable innovations (2014: 96-102). Both titles reference what Fred Block has called "the hidden developmental state" in the United States, which is associated with the tendency for the federal government to quietly intervene in the economy on behalf of commercial interests (2008; see also Campbell et al. 1991).

Aside from the US, it is arguable that the "hidden developmental state" exists in every nominally liberal country. For instance, Peter Hall found ample evidence of state attempts at *Governing the Economy* in a book of that namesake in both interventionist France and liberal Britain, which held over in the latter despite the ideological revolution toward Thatcherism in 1979 (1986: 110-15). Likewise, Bruce Doern and Brian Tomlin found that, contrary to expectations, protectionism was sustained in Canada despite the negotiation of the 1989 Canada-United States Free Trade Agreement (CUFTA) and the 1994 North American Free Trade Agreement (NAFTA) (1996; see also Howse & Chandler 1997). Research has also found that the central government is not always the principal actor when it comes to intervention. Owing to relative powers of taxation and constitutional responsibility over many areas of fiscal policy, provincial governments in Canada have been at least as interventionist as the federal government (Conteh 2013; Lester 2018; Wolfe & Lucas 2004). Moreover, the invisibility of intervention in nominally liberal countries may be enhanced by the fact that interventions tend to be sector-specific as opposed to part of an over-arching industrial strategy (Goracinova et al. 2016; Vogel

1987). Finally, technology incubators, which feature in both liberal and coordinated economies, are intended to produce positive network externalities and complementarities, even when established with vague objectives in mind (Bergek & Norrman 2008).

These manifold interventions may be interpreted as selective departures from a jurisdiction's primary mode of coordination. From such a viewpoint, insofar as selective implementation of beneficial constraints can be considered a mixed strategy in the context of asymmetric growth theory, the perspectives interrogated in this paper are not necessarily incompatible. Of course, not all institutional combinations will be complementary, and substantial ambiguity remains regarding what qualifies as a winning mix (Kenworthy 2006). Fortunately, aside from offering some indication of what constitutes a complementary combination, Witt and Jackson (2016) articulate plausible institutional measures with which to test the robustness of their findings that comparative advantage may follow from any of the three institutional configurations discussed above (cf. Rodrik 1997).

Unfortunately, less progress has been made regarding valid measures of innovation. Consider the NBER Herfindahl indices of "generality" and "originality" that have featured in several prior studies, reproduced here in Equations 2 and 3.

$$GENERALITY_i = 1 - \sum_{k=1}^{N_i} \left(\frac{\text{NCITING}_{ik}}{\text{NCITING}_i} \right)^2 , \tag{2}$$

where NCITING refers to the number of citations received by a patent i, and N_i represents the number of different technology classes k from which patent i receives citations. In plain terms, generality is a measure of forward citations weighted by the range of technology classes to which citing patents belong.

$$ORIGINALITY_i = 1 - \sum_{k=1}^{N_i} \left(\frac{\text{NCITED}_{ik}}{\text{NCITED}_i} \right)^2 , \tag{3}$$

where NCITED refers to the number of patents cited by patent i. Originality is thus a measure of backward citations weighted by the range of technology classes to which cited patents belong (cf. Trajtenberg et al. 1997).

An underlying assumption when using generality and originality as a proxy for radicality is that intellectual content is more radical when it comes from, or diffuses to, a wide range of technological domains. Although several authors have argued that the extent to which an idea is radical is a function of breadth of the technological base from which the idea inherits its intellectual content, as assumed by the originality measure, diffusion to a wide range of technology domains is arguably a more intuitive indicator of radical disruption, per generality (cf. Akkermans et al. 2009; Kaplan & Vakili 2015).[2] Yet, one may question whether breadth of the technology domain is a necessary feature of innovation at all. Indeed, the NBER measures were originally devised to assess a patent's "basicness" (Trajtenberg et al. 1997). Moreover, at least insofar as the sample of pharmaceutical patents analyzed is this paper is concerned, the two measures are only very weakly correlated, with a Pearson correlation coefficient of 0.10.

Intuition aside, the methodological literature has recently found both technology classification schemes and citation counts to be biased estimators. Regarding technological classification, Marco Younge and Jeffry Kuhn found USPTO classification to be a crude measure of technological similarity, concluding that "the patent classification system may work well for identifying functional characteristics of a focal patent, but our results suggest that it does not work well for identifying near-neighbors... in other words, a categorical assignment may be helpful for the USPTO when assigning a patent application to an art unit for examination, but be problematic for scholars when examining problems that are relational" (2016: 21; see also Lafond & Kim 2019). Moreover, in a follow up study on the scope of legal protection afforded by patents, Jeffry Kuhn and Neil Thompson found that "previous measures of patent scope (i.e. the number of patent classes, the number of citations made by future patents, and the number of claims in a patent) are uninformative or misleading"; specifically, "the number of patent classes assigned to a patent is *negatively* correlated with patent scope, the reverse of what is typically assumed [while] the number of citations to a patent is only incredibly weakly (and statistically insignificantly) related to patent scope" (2017: 3, italics and parentheses in original).

More problematically, citation-based indicators are plagued by considerable noise and other sources of bias (Silverberg & Verspagen 2007). As is well known, the average number of citations per patent has increased dramatically over time, creating a heteroskedasticity issue that arguably necessitates the use of deflators to make observations comparable (B. Hall et al. 2001). A less tractable problem follows from the fact that the vast majority of citations are not identified by inventors but rather examiners employed by patent offices. Aside from the fact that examiner bias will almost certainly be non-uniform across patent office personnel, if citations are considered to represent intellectual heritage, citations to prior art added by anyone other than the inventor wreak havoc on the construct validity of the indicator (Criscuolo & Verspagen 2008). As pointed out by Jeffry Kuhn, Kenneth Younge and Alan Marco, although recent data purport to distinguish between citations submitted by applicants and examiners (albeit with some

[2] As put by Acemoglu, Akcigit and Celik, "radical innovation... involves combining diverse ideas to generate a technological improvement in a new area… radical innovations generate higher quality (more highly-cited) patents and tend to be more general in terms of the range of citations they receive (because they are expanding into new areas). This provides us with a strategy to measure the creativity of innovations and investigate the empirical implications of the model" (2020: 1, parentheses in original).

incidence of misattribution), many citations attributed to applicants are added long after the patent is filed, raising further questions about construct validity (2019: 10).

Although citation and classification data will likely have a role to play in future patent research, alternative text-based methods have recently been devised that avoid, either partly or entirely, problems surrounding technological classification and patent citations (Arts et al, 2018; 2020; Kaplan & Vakili 2015). For instance, Sam Arts and colleagues have devised a measure of patent radicality premised on n-gram diffusion, which tracks a patent's contribution to the vocabulary of intellectual content (i.e., the number of new terms contributed by the patent), weighted by the proportion of future patents that contain terms originating in the focal patent. Equation 4 is adapted from Arts et al (2020: 3):

$$RADICALITY_p = \sum_{i=1}^{n} (1 + m_i) \, , \tag{4}$$

where n represents the number of new n-grams (i.e., terms) i introduced by patent p, and m_i represents the number of future patents containing n-grams i introduced by patent p.

The following analyses employ both citation-based and text-based measures of innovation to assess which of the three perspectives —asymmetric growth, varieties of capitalism or beneficial constraints— is most consistent with the data. Fuzzy-set, network analytic and structural equation modelling finds only weak support for the premise that liberal institutions are necessary for radical innovation. Case analysis of a radical Swiss patent reveals that high-powered incentives were but one factor that influenced innovation. Public goods, norms and non-market institutions that shielded the inventor from risk were also at play.

3 Analysis

The following subsections assess the correspondence between institutions and the radicality of pharmaceutical patents filed with the USPTO using institutional indices developed by Witt and Jackson (2016). The sample consists of all patents related to anti-viral medicines, anti-allergic agents, immunomodulators and anti-depressants (N = 55,255). Pharmaceutical patents were selected because asymmetric growth theorists consider pharmaceuticals to be exemplary of their thesis. Pharmaceuticals also represent an industry in which there is competition to produce breakthrough innovations and win patent races. Unlike other industries where patents may not adequately capture innovation advantage, patents should exhibit high construct validity as a measure of innovation in the pharmaceutical industry. Moreover, in most cases, it is safe to assume that drugs will be commercialized in the country of the patent assignee, which tend to be established pharmaceutical firms.

The analyses employ both text-based and citation-based measures of radicality, which is necessary to assess robustness. As shown in Figure 5, there is little correlation between text-based and citation-based measures of innovation, which suggests that each measure is largely independent of the other. Several analytical techniques are also employed to confirm the robustness of the findings, namely fuzzy-set analysis, structural equation modelling and network analysis (i.e., random graph comparisons and survival analysis). Finally, case analysis of the outlying Swiss patent, "Recombinant DNA molecules and their use in producing human interferon-like polypeptides," is undertaken in order to test for the operation of causal mechanisms outlined in the section on microfoundations.

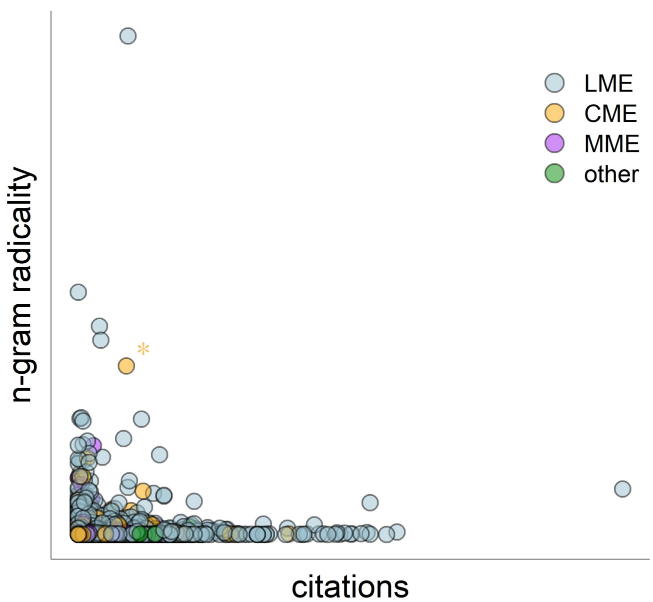

Figure 5: Correlation between textual and citation-based measures of patent radicality

Patents that receive a high number of citations are not strongly correlated with patents that exhibit high scores for n-gram radicality (Pearson correlation coefficient = 0.08). Click figure to explore interactive features. Points classified by country of assignee. Hover over points to reveal country of first listed inventor. N-gram radicality is the sum of unigram radicality, bigram radicality and trigram radiality (see Equation 4). Liberal market economies (LME): Australia, Canada, Ireland, New Zealand, United States, United Kingdom. Coordinated market economies (CME): Austria, Belgium, Denmark, Germany, Finland, Japan, South Korea, Netherlands, Norway, Sweden, Switzerland. Mixed market economies (MME): France, Greece, Italy, Portugal, Spain. Asterisk denotes the Swiss patent, "Recombinant DNA molecules and their use in producing human interferon-like polypeptides," which is chronicled in the validation study below (Section 3.4).

Textual data were collected by scraping the USPTO Full Text and Image Database. Patents issued prior to 1976 were downloaded as scanned images, read using an optical character recognition algorithm and manually cleaned. The text for each patent was then processed using stopword dictionaries and code courtesy of Sam Arts, Jianan Hou and Carlos Gomez, who also developed the code used to track the genesis and diffusion of n-grams across patent texts over time (2020: 2-4). Citation and technology classification data were downloaded from the [Google Patents Public Dataset] using BigQuery. All code and datasets, including additional stopwords necessary to reduce noise, are available in the [online supplement].

Figures 6 and 7 present descriptive statistics for both measures of innovation. Text-based measures of n-gram radicality were calculated for each patent based on n-grams containing one to three terms (see Equation 4). Such an approach is necessary to capture both single-word and multi-word expressions. Institutional measures of countries' position on the market to non-market continuum were calculated by summing country scores across the five institutional indices given by Witt and Jackson (2016), which are reproduced in Tables 1 and 2 below.

As seen in Figures 6 and 7, although the United States —the leftmost LME in each panel— has the highest values on both text-based and citation-based measures of patent radicality, it is by no means the sole jurisdiction from which radical patents are filed. As demonstrated further in the discussion section below, the data do not confirm neatly to any of the hypothesized patterns presented in Figure 2, which suggests that none of the three theories —asymmetric growth, varieties of capitalism, beneficial constraints— is unequivocally correct. Going beyond descriptive statistics, the following subsections demonstrate the same using more rigorous analytic techniques.

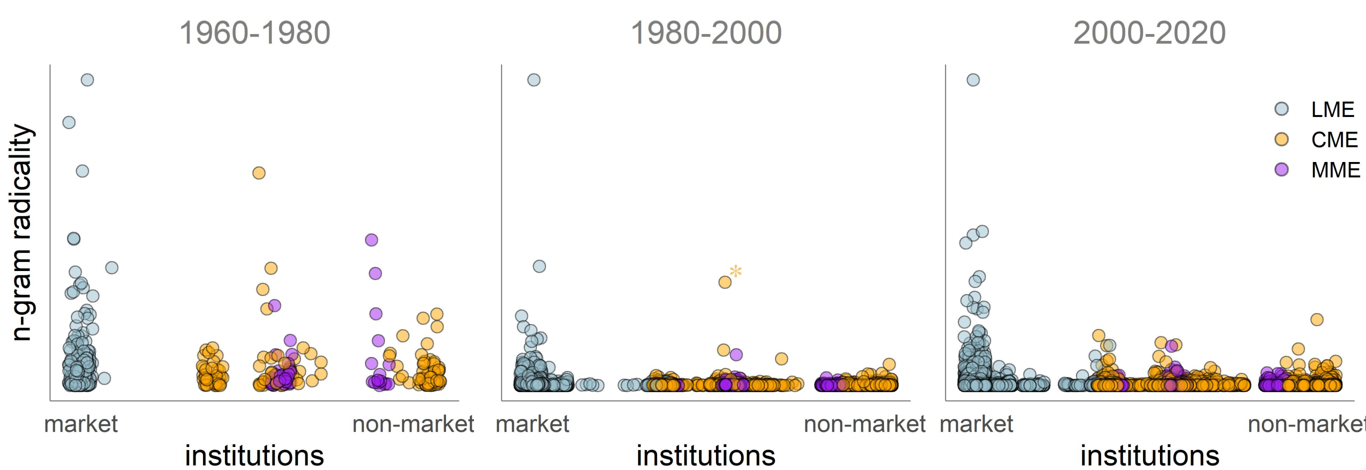

Figure 6: Institutions and text-based measures of patent radicality, three periods

Click figure to explore interactive features. Points classified by country of assignee. Hover over points to reveal country of first listed inventor. Radicality is the sum of unigram radicality, bigram radicality and trigram radiality (see Equation 5). Horizontal axis values calculated by summing institutional indices from Witt and Jackson (2016). Asterisk in middle panel denotes the Swiss patent, "Recombinant DNA molecules and their use in producing human interferon-like polypeptides," which is chronicled in the validation study below (Section 3.4).

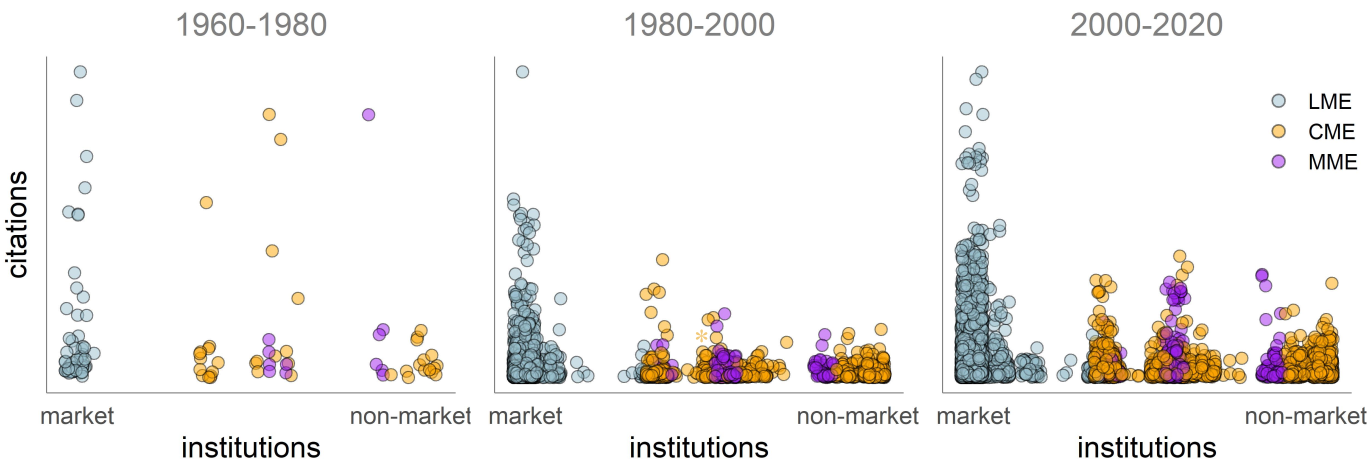

Figure 7: Institutions and citation-based measures of patent radicality, three periods

Click figure to explore interactive features. Points classified by country of assignee. Hover over points to reveal country of first listed inventor. Vertical axis values are total forward citations per patent as of December 2020. Horizontal axis values calculated by summing institutional indices from Witt and Jackson (2016). Asterisk in middle panel denotes the Swiss patent, "Recombinant DNA molecules and their use in producing human interferon-like polypeptides," which is chronicled in the validation study below (Section 3.4).

3.1 Fuzzy-set analysis

The set-theoretic intuition of fuzzy-set analysis is identical to that of a Venn diagram: observations belong to one or more categories called sets, whereby sets overlap (i.e., intersect) when they share observations (Ragin 2000). The "fuzzy" part of fuzzy-set analysis follows from the calibration of quantitative measures corresponding to observations' degree of membership in sets, which entails establishing thresholds for full membership in a set, full non-membership in a set and a crossover point between membership and non-membership (Ragin 2008: 85). Overall goodness of fit is assessed by calculating consistency and coverage, whereby consistency measures the extent to which hypothesized set relations exist (i.e., extent of intersection), while coverage measures the proportion of observations that fall within hypothesized set relations (Ragin 2006).

In a test of whether a condition or combination of conditions is necessary for an outcome (e.g., that market-based institutions are necessary for radical innovation),

$$CONSISTENCY\ (y_i \leq x_i) = \sum(\min(x_i, y_i)) / \sum(y_i)\,, \tag{5}$$

$$COVERAGE\ (y_i \leq x_i) = \sum(\min(x_i, y_i)) / \sum(x_i)\,, \tag{6}$$

where i represents observations in sets x and y, and x_i and y_i represent membership scores of observations in the corresponding sets. In a necessity test, full consistency obtains when all y_i values are less than or equal to corresponding x_i values, denoting a subset relation. Full coverage obtains only when consistency is perfect (i.e., when subset relation exists) and when sets x and y are of equivalent size (i.e., when x is a subset of y and vice versa).

Both consistency and coverage take on values between 0 and 1. As a general rule, consistency scores less than 0.75 are considered insignificant, while scores above 0.85 are considered highly significant (cf. Ragin 2008: 135-36). Thus, it is pointless to interpret coverage scores when consistency is below the 0.75 cut-off, as consistency measures the incidence of the hypothesized relationship while coverage assesses the non-triviality of the relationship (Ragin 2000: 98).

Eschewing binary LME-CME country classifications, fuzzy-set scores for institutional variables were adopted from Witt and Jackson (2016: 793). Witt and Jackson's institutional indices represent prevalence of non-market institutions in areas of corporate governance, inter-firm relations, employment relations, education and training, and firm hierarchy.[3] However, whereas Witt and Jackson use time-variant indices in their analysis, time-variant data do not exist for the period under analysis. Although imperfect, country averages based on values for 1995-2003 are the best indicators available to measure degree of market versus non-market institutions.

Unlike Witt and Jackson, who consider observations in the bottom 25% of their citation measure to be "fully out" of the set of radically-innovative patents and observations in the top 75% to be "fully in" the set, the results reported in Table 1 are based on observations in the top 10% being considered "fully in" the set of radically innovative patents, patents with no citations being "fully out" of the set, and the 50th percentile value as the crossover point (cf. Witt & Jackson 2016: 791). Calibration along these lines is appropriate given the skewness of the distribution. As shown in Figure 5, the vast majority of patents receive no citations while a small fraction receive more than a hundred. For the same reason, calibration of text-based measures of innovation is similarly based on observations in the top 10% being considered "fully in" the set of radically innovative patents, patents with n-gram radicality scores of zero being "fully out" of the set, and the 50th percentile value as the crossover point.

[3] Corporate governance is a function of shareholder protection, dispersion of control, and the size of the stock market. Inter-firm relations are a function of mergers and acquisitions. Employment relations are a function of wage coordination, incidence of short-term employment, and employment protection. Firm hierarchy is a function of board-level co-determination. Education and training is a function of works council rights, occupational and university training (see Witt & Jackson 2016: 791).

Table 1: fuzzy-set analysis of the effect of institutional configuration on patent citations

country	occ train	firm hier	inter firm rel	emp rel	corp gov	cons 1960-1990	cov 1960-1990	cons 1970-2000	cov 1970-2000	cons 1980-2010	cov 1980-2010	cons 1990-2020	cov 1990-2020	full period cons	full period cov	n	per 1000 pop
USA	0.05	0	0.07	0.19	0.01	0.51	0.96	0.76	0.58	0.77	0.51	0.62	0.84	0.62	0.77	23877	0.07
UK	0.05	0	0.07	0.22	0.01											2148	0.03
Canada	0.05	0	0.19	0.22	0.10	0.58	0.95	0.80	0.53	0.81	0.47	0.71	0.83	0.70	0.76	805	0.02
Australia	0.07	0	0.17	0.33	0.08											467	0.02
Ireland	0.04	0.05	0.06	0.41	0.29	0.58	0.96	0.81	0.53	0.83	0.47	0.72	0.83	0.72	0.76	208	0.04
N. Zealand	0.04	0	0.35	0.22	0.61	0.11	0.98	0.14	0.66	0.13	0.59	0.10	0.88	0.10	0.84	39	0.01
Spain	0.13	0.20	0.63	0.17	0.45	0.18	0.97	0.23	0.71	0.23	0.65	0.16	0.90	0.17	0.86	336	0.01
France	0.38	0.60	0.40	0.38	0.40	0.27	0.96	0.20	0.48	0.18	0.43	0.16	0.86	0.17	0.81	2343	0.04
Portugal	0.02	0.05	0.83	0.57	0.77	0.11	0.98	0.13	0.68	0.12	0.64	0.08	0.90	0.08	0.86	14	0.00
Greece	0.16	0.05	0.75	0.83	0.85											4	0.00
Italy	0.72	0.20	0.49	0.86	0.79	0.17	0.97	0.17	0.62	0.16	0.56	0.12	0.88	0.12	0.84	779	0.01
Japan	0.11	0	0.61	0.70	0.11	0.20	0.96	0.24	0.69	0.24	0.64	0.16	0.89	0.17	0.86	2790	0.02
S. Korea	0.28	0	0.71	0.22	0.40	0.21	0.96	0.25	0.68	0.25	0.62	0.17	0.89	0.18	0.85	402	0.01
Finland	0.19	0.73	0.14	0.36	0.40	0.15	0.97	0.14	0.57	0.13	0.51	0.10	0.87	0.10	0.82	48	0.01
Switzerland	0.74	0.27	0.28	0.57	0.18	0.26	0.97	0.27	0.62	0.26	0.58	0.19	0.89	0.20	0.85	1221	0.14
Denmark	0.17	0.73	0.36	0.30	0.61	0.11	0.97	0.11	0.62	0.10	0.55	0.07	0.88	0.08	0.83	526	0.09
Sweden	0.41	0.73	0.22	0.60	0.30	0.20	0.97	0.17	0.55	0.16	0.48	0.12	0.87	0.13	0.82	528	0.05
Netherlands	0.26	0.80	0.28	0.70	0.40											518	0.03
Norway	0.13	0.73	0.44	0.59	0.79	0.11	0.97	0.11	0.63	0.10	0.57	0.07	0.88	0.07	0.84	89	0.02
Belgium	0.70	0.40	0.45	0.86	0.83	0.17	0.96	0.17	0.62	0.16	0.56	0.12	0.88	0.12	0.84	918	0.08
Germany	0.83	0.95	0.63	0.74	0.36	0.17	0.96	0.15	0.58	0.14	0.53	0.10	0.87	0.11	0.83	2831	0.03
Austria	0.90	0.95	0.63	0.74	0.90	0.13	0.97	0.12	0.62	0.11	0.55	0.08	0.88	0.08	0.84	191	0.02

Source: USPTO patents classified A61P37/02, 37/08, 31/12, 25/24 (USPTO 2021). Scores based on necessity tests using R package QCA (Duşa & et al 2013). Institutional scores adapted from Witt and Jackson (2016: 791): *occupational training* = min(*upper/post-secondary graduates/graduation age pop, tertiary graduates/graduation age pop*); *firm hierarchy* = min(*board-level co-determination, works council rights*); *inter-firm relations* = min(*mergers and acquisitions/GDP, proportion complete takeover M&A transactions*); *employment relations* = min(*wage coordination, short-term employment, employment protection*); *corporate governance* = min(*shareholder protection, dispersion of control, stock market size*). Outcome variable is the sum of forward citations per patent. Patents in top 10% of cited patents= fully in; patents with zero citations = fully out; 50th percentile value = crossover point. Institutional configurations: < 0.20 = absence of condition, 0.20-0.50 = neither absence nor presence of condition, > 0.50 = presence of condition. 18 configurations identified: {UK, Canada, Australia}, {Portugal, Greece}, {Sweden, Netherlands} and 15 unique national configurations. Based on country of assignee; nearly identical results obtain using country of first listed inventor. Data and code available in supplement.

Table 2: fuzzy-set analysis of the effect of institutional configuration on text-based measures of patent radicality

country	occ train	firm hier	inter firm rel	emp rel	corp gov	cons 1960-1990	cov 1960-1990	cons 1970-2000	cov 1970-2000	cons 1980-2010	cov 1980-2010	cons 1990-2020	cov 1990-2020	full period cons	full period cov	n	per 1000 pop
USA	0.05	0	0.07	0.19	0.01	0.68	0.59	0.75	0.55	0.75	0.53	0.76	0.51	0.80	0.39	23877	0.07
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Belgium	0.70	0.40	0.45	0.86	0.83	0.26	0.69	0.20	0.68	0.18	0.66	0.18	0.68	0.21	0.58	918	0.08
Germany	0.83	0.95	0.63	0.74	0.36	0.24	0.62	0.17	0.63	0.16	0.63	0.15	0.64	0.18	0.53	2831	0.03
Austria	0.90	0.95	0.63	0.74	0.90	0.20	0.68	0.14	0.68	0.13	0.68	0.12	0.69	0.15	0.59	191	0.02

Source: USPTO patents classified A61P37/02, 37/08, 31/12, 25/24 (USPTO 2021). Scores based on necessity tests using R package QCA (Duşa & et al 2013). Institutional scores adapted from Witt and Jackson (2016: 791): *occupational training* = min(*upper/post-secondary graduates/graduation age pop, tertiary graduates/graduation age pop*); *firm hierarchy* = min(*board-level co-determination, works council rights*); *inter-firm relations* = min(*mergers and acquisitions/GDP, proportion complete takeover M&A transactions*); *employment relations* = min(*wage coordination, short-term employment, employment protection*); *corporate governance* = min(*shareholder protection, dispersion of control, stock market size*). Outcome variable is the sum of radicality scores for *unigrams, bigrams* and *trigrams* (see Equation 5). Patents in top 10% = fully in radicality set; patents with radicality score of zero = fully out; 50th percentile value = crossover point. Institutional configurations: < 0.20 = absence of condition, 0.20-0.50 = neither absence nor presence of condition, > 0.50 = presence of condition. 18 configurations identified: {UK, Canada, Australia}, {Portugal, Greece}, {Sweden, Netherlands} and 15 unique national configurations. Based on country of assignee; nearly identical results obtain using country of first listed inventor. Data and code available in supplement.

Set membership scores for each institutional indicator are also given by country in Tables 1 and 2, whereby country attribution is based on the address of the assignee. As shown in the supplement, using the address of the first listed inventor yields nearly identical results. Following Witt and Jackson, country configurations were calculated such that countries with scores < 0.20 on an institutional indicator are considered to exhibit an absence of the condition, countries with scores between 0.20 and 0.50 are considered to exhibit neither the absence nor presence of the condition, and countries with scores > 0.50 are considered to exhibit the presence of the condition (2016: 793). As shown in Tables 1 and 2, the scheme produces 18 country configurations. Unlike Witt and Jackson, who assess whether institutional configurations are sufficient to produce radical innovation, Tables 1 and 2 report tests of necessity. Assessment of necessary conditions is appropriate if the purpose of the research is to evaluate the claim, made by asymmetric growth theorists, that market-based institutions are necessary for radical innovation.

The information reported in Tables 1 and 2 reveals that the United States dominates in terms of the number of pharmaceutical patents filed, followed by Japan and Germany. However, if considering patents filed per capita, Switzerland scores highest, followed by Denmark, Belgium and the United States (at 0.14, 0.09, 0.08, and 0.07 patents per thousand people). Insofar as liberal institutions are a necessary condition for radical innovation, consistency and coverage scores are suggestive but weak: the 0.75 consistency threshold for significance is barely surpassed in most cases (only those cases with consistency and coverage scores in bold in Tables 1 and 2). Moreover, the 0.85 threshold for high significance is not met. Liberal institutions may therefore be considered necessary for radical innovation only if necessity is defined in probabilistic terms (Ragin 2000: 212-29). Interestingly, the text-based measure of innovation performs better than citation-based measures of innovation. As shown in the supplement, the result is sustained using citation deflators courtesy of Bronwyn Hall, Adam Jaffe and Manuel Trajtenberg (2001), as well as Herfindahl indices of patent generality (Equation 2) and originality (Equation 3).

To test for undue influence on the part of US cases, the analysis was repeated with US patents omitted from the samples (see supplement). Liberal configurations remained better performing than all others in terms of consistency and coverage, but consistency scores fell below the minimum threshold for significance (cf. Taylor 2004). Insofar as fuzzy-set analysis is concerned, the finding that liberal institutional configurations perform better than any other in terms of producing radical innovation appears to be robust to changes to the model's parameters. Yet, within the liberal configuration, the United States does not always score highest on consistency and coverage, which may suggest support for the beneficial constraints argument.

3.2 Structural equation modelling

Structural equation modelling employs statistical methods to generate regression estimates that measure relationships between latent (unobserved) and manifest (observed) variables. Manifest variables are assumed to be caused by one or more latent independent variables, which in turn are assumed to cause a manifest dependent variable (Kaplan 2009). The first step of the analysis entails running confirmatory factor analysis on Witt and Jackson's (2016) institutional measures in order to generate a latent variable representative of the degree to which institutions are market-based or non-market. The second step is a simple linear regression whereby the latent institutional measure represents the independent variable, while a measure of patent radicality represents the dependent variable (whether text-based or citation-based).

As shown in Table 3, Witt and Jackson's country scores factor load unproblematically onto a single latent dimension, whereby lower scores denote market-based institutions and higher scores denote non-market institutions. Given that the distribution of the dependent variable is heavily skewed, a logarithmic transformation is appropriate. However, because zero values are substantively relevant, it is necessary to apply a small constant (i.e., 0.1) to radicality scores, else zero values will be dropped in the logarithmic transformation.

Table 3 reports standardized factor loadings and standardized regression coefficients, along with goodness of fit statistics, for five models. The first model, denoted by the "text" column, has as its dependent variable the n-gram radicality score given in Equation 4. The second model, denoted "citations," has as its dependent variable patents' raw citation counts. The third model, denoted "cit-def," employs citation deflators on raw citation counts (cf. B. Hall et al 2001). The fourth model, denoted "generality," has as its dependent variable the generality score given in Equation 2. The fifth model, denoted "originality" has as its dependent variable the originality score given in Equation 3. Factor loadings are given in the leftmost column, which are well above the 0.3 minimum threshold for suitable loading (Hair et al. 1995).

The standardized coefficients given in Table 3 estimate the standard deviation change in the dependent variable for each standard deviation increase in the institutional variable. The results indicate a statistically significant but substantively weak relationship. Indeed, the largest estimate, −0.13, conveys that patent radicality declines by 0.13 standard deviations for each standard deviation increase on the institutional variable. Substantively, a four standard deviation change from market-based to non-market institutions corresponds with a mere 0.52 standard deviation reduction in patent radicality. The goodness of fit statistics —comparative fit index (CFI) and Tucker Lewis Index (TFI)— although somewhat close to 1 (which would denote perfect model fit), fall below the standard 0.9 threshold for very good fit. Meanwhile, some of the badness of fit statistics —root mean square error of approximation (RMSEA) and standardized root mean square residual (SRMR)— fall above the 0.1 threshold for very good fit.

	loadings
occ train	0.75
firm hier	0.86
inter-firm rel	0.80
emp rel	0.91
corp gov	0.90

	text	citations	cit-def	generality	originality
institutions	−0.03**	−0.10***	−0.13***	−0.12***	−0.11***
CFI	0.85	0.89	0.87	0.88	0.88
TLI	0.75	0.81	0.79	0.79	0.79
RMSEA	0.29	0.23	0.25	0.25	0.25
SRMR	0.05	0.04	0.04	0.04	0.04

Table 3: Structural equation model results, citation and text-based measures

Dependent variable is the natural logarithm of the radicality score. Standardized loadings and standardized coefficients reported. Model "cit-def" includes observations for the 1977-2012 period only. ** = $p < 0.05$, *** = $p < 0.01$. Calculated using the R package Lavaan.

These results are consistent with the findings from the fuzzy-set analysis: they convey correspondence, albeit weak, between market-based institutions and patent radicality. Unlike the results from the fuzzy-set analysis, which found stronger correspondence between institutions and text-based measures of innovation, the results from the structural equation models indicate a stronger relationship between institutions and citation-based measures of innovation.

3.3 Network analysis

Network-analytic methods may be invoked to assess the diffusion of knowledge flows between countries of various institutional types. Two such methods are employed here: random graph comparisons and survival analysis. Random graph comparisons are useful for discerning whether observed networks of citation and n-gram flows differ non-trivially from a null distribution of networks randomly-generated from the data.[4] Survival analysis is useful for ascertaining whether institutional covariates affect the duration of intellectual diffusion, as measured by patent citations and n-gram flows.

Table 4 displays mixing matrices of observed citation flows and those predicted by random graphs. Comparison of diagonal values between the two exhibits in Table 4 reveals that real-world citation flows occur between countries of the same institutional type with much greater frequency than would occur by random chance. The inference is that diffusion tends to be geographically concentrated (cf. Kwon et al. 2020).

[4] Erdős-Rényi random graphs take observed nodes (with metadata), and generate random graphs with the same number of edges as the observed network. Thus, the random component corresponds with edge assignment between nodes.

observed flows

from \ to	CME	LME	MME	other
CME	3191	4783	587	109
LME	5153	45020	2442	733
MME	349	1221	675	30
other	233	945	72	846

random graph flows

from \ to	CME	LME	MME	other
CME	3047	9604	1093	528
LME	9590	29824	3399	1678
MME	1073	3421	386	193
other	540	1674	194	90

Table 4: Mixing matrices of patent citations between country types

Values in right exhibit produced by averaging values across repeated simulations of Erdős-Rényi random graphs based on the observed citation network. Comparison of diagonal values indicate a tendency for patents to cite patents from the same country type. Based on country of assignee. Similar results obtain using country of first listed inventor (see supplement). Liberal market economies (LME): Australia, Canada, Ireland, New Zealand, United States, United Kingdom. Coordinated market economies (CME): Austria, Belgium, Denmark, Germany, Finland, Japan, South Korea, Netherlands, Norway, Sweden, Switzerland. Mixed market economies (MME): France, Greece, Italy, Portugal, Spain.

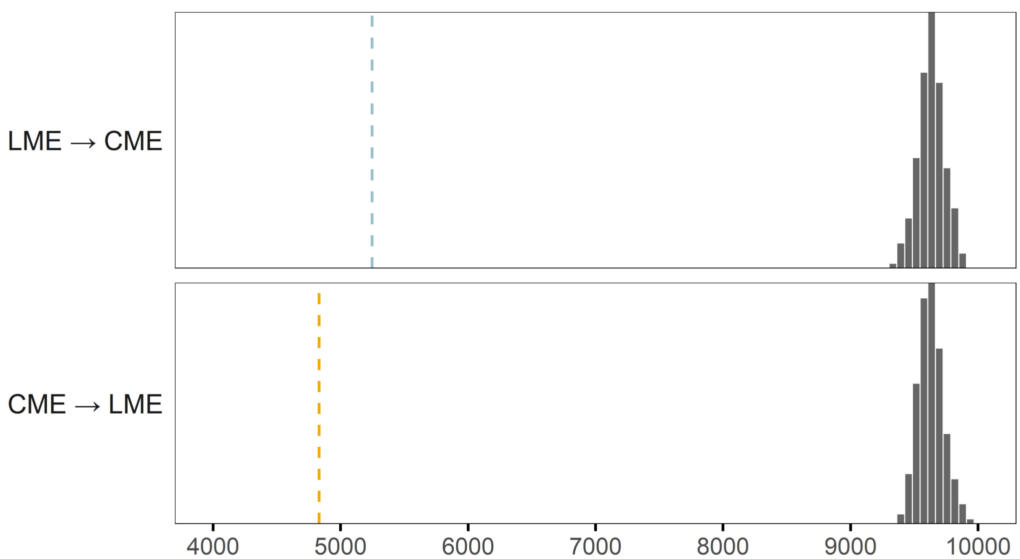

Figure 8: Random graph versus observed citations between LMEs and CMEs

Shaded distributions generated from simulated Erdős-Rényi random graphs based on the observed citation network. Dashed lines represent observed incidence of citations between country types. Observed citations are significantly less frequent than values predicted by random graphs (see Table 4). Based on country of assignee. Similar results obtain using country of first listed inventor (see supplement). Liberal market economies (LME): Australia, Canada, Ireland, New Zealand, United States, United Kingdom. Coordinated market economies (CME): Austria, Belgium, Denmark, Germany, Finland, Japan, South Korea, Netherlands, Norway, Sweden, Switzerland.

Assessing the hypothesis that knowledge tends to flow from liberal to coordinated countries, as predicted by asymmetric growth and varieties of capitalism theory, is a simple matter of comparison. Figure 8 provides a graphical representation of citation flows from liberal to coordinated countries and vice versa, relative to the random graph null distribution. In both cases, random graphs predict much higher incidence of citation flows between countries of different institutional types than are observed. This finding follows from the localized nature of citation flows. As shown by the difference in the position of the vertical dashed lines in Figure 8, citation flows from liberal to coordinated countries are slightly more frequent than citation flows from coordinated to liberal countries.

Different results obtain when using incidence of n-gram diffusion as the dependent variable. As shown in Table 5, there is no strong tendency for n-grams to diffuse between countries of the same institutional type. Moreover, as shown in Figure 9, whereas observed n-gram flows from coordinated to liberal countries occur with lesser frequency than would occur by random chance, n-gram flows from liberal to coordinated countries occur with greater frequency.

from \ to	CME	LME	MME	other
CME	4900	9236	1678	2010
LME	11810	37017	4620	749
MME	1039	2375	642	51
other	370	1101	144	42

observed flows

from \ to	CME	LME	MME	other
CME	3780	11308	1428	409
LME	11316	33922	4293	1249
MME	1444	4286	553	157
other	414	1226	157	45

random graph flows

Table 5: Mixing matrices of n-gram diffusion between country types

Based on sample of n-gram diffusion values ≥ 500 due to computational limitations. Values in right exhibit produced by averaging values across repeated simulations of Erdős-Rényi random graphs derived from the observed n-gram diffusion network. Based on country of assignee. Similar results obtain using country of first listed inventor (see supplement). Liberal market economies (LME): Australia, Canada, Ireland, New Zealand, United States, United Kingdom. Coordinated market economies (CME): Austria, Belgium, Denmark, Germany, Finland, Japan, South Korea, Netherlands, Norway, Sweden, Switzerland. Mixed market economies (MME): France, Greece, Italy, Portugal, Spain.

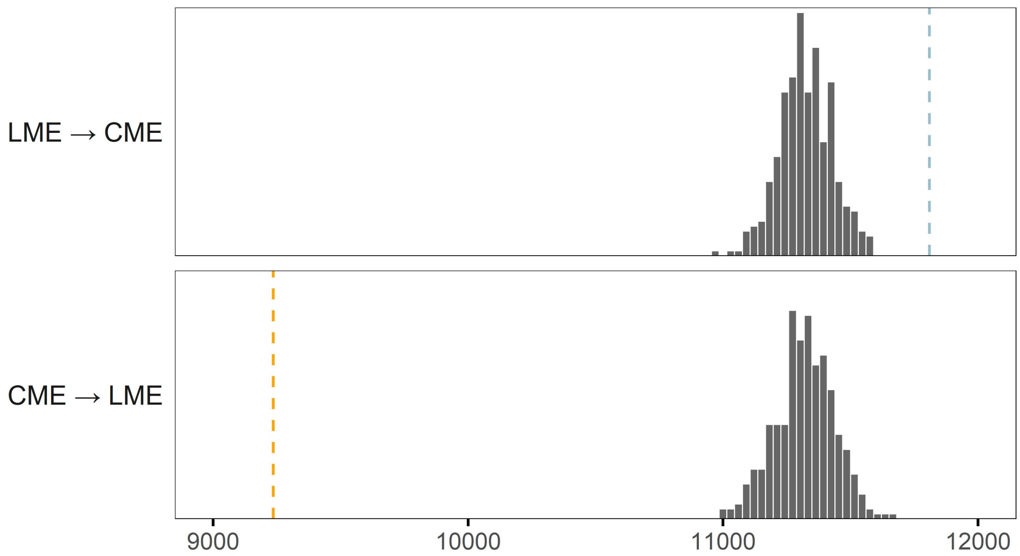

Figure 9: Random graph versus observed n-gram flows between LMEs and CMEs

Based on a sample of n-gram diffusion values ≥ 500 due to computational limitations. Shaded distributions generated from simulated Erdős-Rényi random graphs based on the observed n-gram diffusion network. Dashed lines represent observed incidence of n-gram diffusion between country types. Observed incidence of n-gram diffusion from LMEs to CMEs is somewhat more frequent than values predicted by random graphs, while observed incidence of n-gram diffusion from CMEs to LMEs is significantly less frequent (see Table 5). Based on country of assignee. Similar results obtain using country of first listed inventor (see supplement). Liberal market economies (LME): Australia, Canada, Ireland, New Zealand, United States, United Kingdom. Coordinated market economies (CME): Austria, Belgium, Denmark, Germany, Finland, Japan, South Korea, Netherlands, Norway, Sweden, Switzerland.

While there is only weak evidence that knowledge tends to flow from liberal to coordinated economies when using citation-based indicators of innovation, the hypothesis finds somewhat stronger support when text-based measures of innovation are employed. The substantive inference is that coordinated economies inherit intellectual content from liberal economies. Omitting the United States from the sample reveals, however, that the finding is driven by American cases (cf. Taylor 2004). With these cases removed, the relationship disappears entirely (see supplement).

Figures 10 and 11 report results from survival analysis using Weibull estimation, controlling for cohort effects. A patent's survival duration (its "relevance") is the difference between the patent's filing date and the filing date of the last patent to cite or reference n-grams introduced by it. As shown in Figures 10 and 11, survival curves for LMEs and CMEs are very similar, whether using citation-based or text-based measures of innovation. The inference to be drawn is that there are no significant differences in patent relevance in terms of survival duration across liberal and coordinated economies.

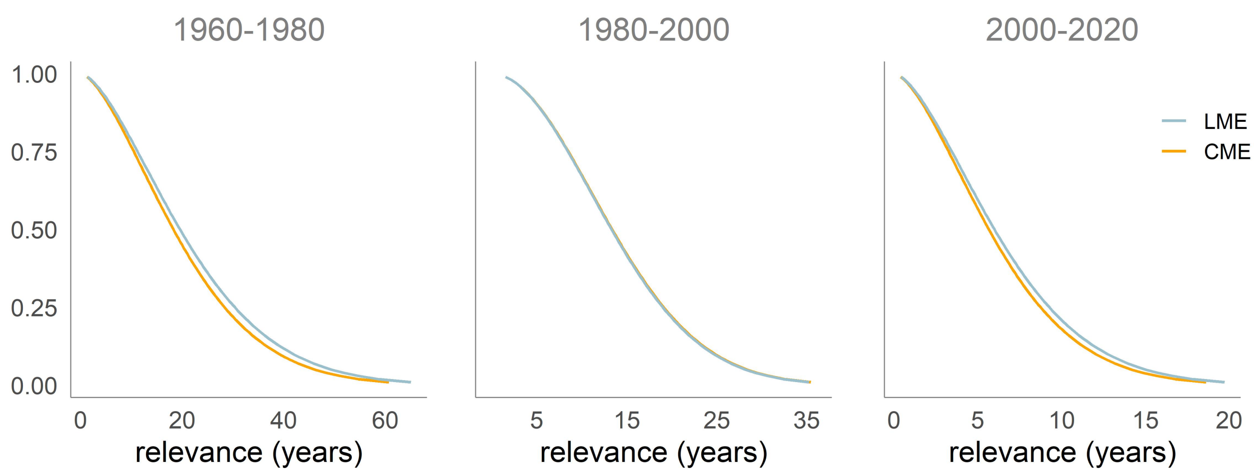

Figure 10: Patent relevance by citation survival duration, three cohorts

Based on Weibull probability estimator of patent citations over time. Patents from LMEs have slightly (trivially) longer relevance, as measured by citation survival duration. Based on country of assignee. Similar results obtain using country of first listed inventor (see supplement). Liberal market economies (LME): Australia, Canada, Ireland, New Zealand, United States, United Kingdom. Coordinated market economies (CME): Austria, Belgium, Denmark, Germany, Finland, Japan, South Korea, Netherlands, Norway, Sweden, Switzerland.

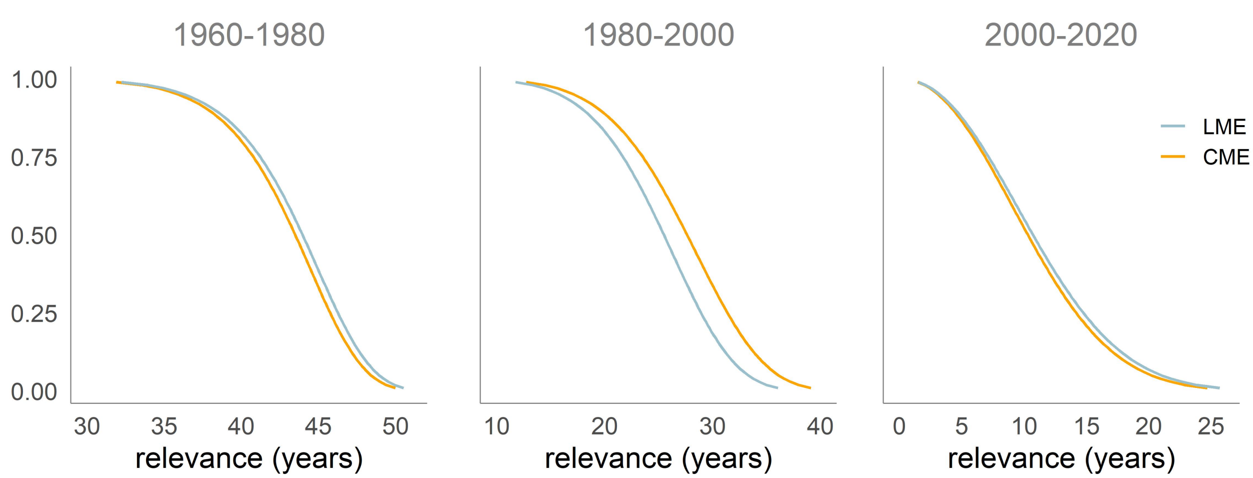

Figure 11: Patent relevance by n-gram survival duration, three cohorts

Based on Weibull probability estimator of n-gram diffusion over time. Patents from LMEs have slightly (trivially) longer relevance, as measured by n-gram survival duration, in the first and third cohorts; patents from CMEs have slightly longer relevance in the second cohort. Based on country of assignee. Similar results obtain using country of first listed inventor (see supplement). Liberal market economies (LME): Australia, Canada, Ireland, New Zealand, United States, United Kingdom. Coordinated market economies (CME): Austria, Belgium, Denmark, Germany, Finland, Japan, South Korea, Netherlands, Norway, Sweden, Switzerland.

3.4 Case study

The preceding analysis indicated a relationship, however weak, between liberal institutions and radical innovation. The tenuousness of the relationship stems from the fact that there are many instances of radical innovation in coordinated economies that are not predicted by the model. Whereas large-N findings shed light on which behavioural hypothesis is more correct overall, cases analysis is useful for ascertaining why and how the model errs by testing for the operation of hypothesized causal mechanisms, which are unobserved in large-N quantitative models (Checkel & Bennett 2015; Lieberman 2005; Mahoney 2008).

The Swiss patent, "Recombinant DNA molecules and their use in producing human interferon-like polypeptides" —which was filed by molecular biologist Charles Weissmann and assigned to Biogen in 1980— is a good candidate for case analysis, as it is a radical patent that originated in a coordinated economy (see Figure 5). Of particular interest is whether high-powered ("cut-throat") incentives played a role in the development of interferon technology, or whether low-powered incentives coincided with network complementarities, as predicted by the "collective action" behavioural hypothesis (see Figure 4).

Interferon technology is a subset of genetic microbiology, which came on the scene following the 1973 Cohen-Boyer discovery that bacterial DNA could be transferred from one organism to another *in vitro*. Efforts at commercializing transgenic discoveries followed when Herbert Boyer co-founded Genentech in San Francisco in 1976.[5] At the time, the Genentech model did not entail capital investments, but rather involved sponsoring research in university laboratories.

After obtaining minority shares in Genentech, two managers of the high-risk investment portfolio for the Canadian-based International Nickel Corporation (Inco), Daniel Adams and Raymond Shaefer, sought to establish a second company —a "clone of Genentech"— by recruiting scientists from the Eastern United States and Europe (Adams 2011: 68, quoted in Dick & Jones 2017: 126). To that end, the pair approached Charles Weissmann at the University of Zurich in early 1977. Although Weissmann is reported to have been initially disinterested in establishing a biotechnology company, Weissmann and several other reluctant European and American scientists are said to have gradually come around to the idea in March 1978 after Adams and Shaefer solicited the interest of famed Harvard and MIT molecular biologists Walter Gilbert and Phillip Sharp as possible co-founders (Dick & Jones 2017: 131).

It was far from clear in 1978 whether commercialization of microbiology would pay dividends. Weissmann, in particular, is remembered as being incredulous toward the prospect of riches. Making money appears to have been at most an ancillary consideration among Biogen's founding scientists, who were chiefly concerned with advancing applied

[5] It would be remiss not to mention that the Cetus Corporation was founded in 1971 by Ronald Cape, Peter Farley and Don Glaser in Berkeley. Stanley Cohen was one of its first advisors.

medicine in a collaborative environment (Dick & Jones 2017: 133). As Phillip Sharp put it, "it was almost a public duty to do it as a scientist, to move this technology into the private sector and try to develop it" (Sharp 2012: 4, quoted in Dick & Jones 2017: 133).

Regarding governance, the institution of a scientific advisory board gave the scientists autonomy over company research with no strings attached in terms of limitations on academic publishing. The scientists operated as consultants with veto power over corporate decisions, as opposed to employees in a hierarchically-organized firm (Dick & Jones 2017: 134). Regarding compensation, while the scientists collected modest salaries for their participation on the scientific advisory board, remuneration primarily took the form of equity shares. Thus, the company would need to be successful for anyone to profit from the Biogen experiment.

Importantly, Weissmann's work on interferons began nine months prior to the establishment of Biogen at the University of Zurich, where the research continued as Biogen got underway. Interestingly, there was much more resistance to commercial research being done by faculty in university labs at Harvard and MIT than there was at the University of Zurich or the University of Geneva. Without incident, Weissmann entered into an agreement with the University of Zurich that permitted up to two days each week to be spent on Biogen business (Dick & Jones 2017: 137). In exchange, the university would receive royalties from any forthcoming product sales. At Harvard, "purist" faculty in the Department of Molecular and Cellular Biology attempted to prevent Walter Gilbert from conducting insulin research on behalf of Biogen (Gilbert 2012). At MIT, university policy barred scientists from conducting research on behalf of companies in which they held equity, thwarting Phillip Sharp's plans to pursue gene expression for bovine growth hormone (Sharp 2012).

Unhindered by colleagues and administrators at the University of Zurich, Weissmann successfully cloned leukocyte interferon in 1980. Biogen then negotiated the sale of 16% of its shares to Schering-Plough for $8 million as a means of raising money and obtaining capital required to commercialize its drugs (Weissmann 2012). Although initial enthusiasm about the possibility that interferons could be used to cure cancer was useful for raising money, that hope was dashed by the mid-1980s (Pieters 2005). Instead, Weissmann's discovery found commercial success, first, as a treatment for hairy cell leukemia and, second, as a treatment for hepatitis C. The result was a billion-dollar market.

4. Discussion

The case study summarized in Section 3.4 revealed two important insights. First, high-powered incentives can exist in nominally-coordinated economies with relatively generous levels of social protection (see Figure 1). Second, low-powered incentives may be more conducive to radical innovation than asymmetric growth theorists suppose.

Many innovations are too risky and too costly for individuals to take on themselves. Rather, public goods and low-powered incentives may provide the scale, scope and cost conditions required for innovation (Chandler 1990).

It would have been unthinkable for Charles Weissmann to assume all the risk involved in pursuing interferon research privately. Even if Weissmann's cost-benefit calculation was favourable, the up front expense of laboratory capital would have constituted an insurmountable barrier to entry. Moreover, the risk that the market for interferons might prove disappointing would have likely discouraged wholesale devotion to interferon research (e.g., commitment of personal savings and time). Instead, low-powered incentives in the form of an academic salary relieved Weissmann of much of the risk associated with the enterprise.

In the context of the formal model laid out in Equation 1, the aggregate expected utilities of the members of the Biogen science board were rendered positive thanks to the externalization of capital costs onto the universities for whom the scientists worked. The opportunity costs of most of the founders were also modest owing to the fact that, with the exception of Phillip Sharp at MIT, they retained all the perks of academic affiliation. Indeed, the founding scientists had little to lose by involving themselves with Biogen, and perhaps much to gain. Moreover, the evidence suggests individual utilities were bolstered by the prospect of network complementarities that coincide with collaboration. Put differently, the formation of Biogen leveraged economies of scope by bringing together human assets that were previously dispersed.

Regarding prospective gain, the Biogen corporate structure was conducive to high-powered incentives in the sense that its founders would yield little profit if the company was unsuccessful. Yet, risk associated with individual projects was pooled such that the value of shares would rise or fall depending on collective, as opposed to individual, success or failure. As in many instances of collective action, the scientists faced prisoner's dilemma: each could individually do better by free-riding on the efforts of other scientists. However, a great deal of trust and respect existed among Biogen's founding members. Furthermore, collaboration was purportedly sustained by a mutual sense of duty to the progression of science. As is well known, trust and duty facilitate cooperative solutions to prisoner's dilemma problems (Axelrod 1984).

Regarding microfoundational theory and the hypothesized causal pathways to innovation outlined in Figure 4, collective action better explains the case than inertia. Veto players with power to block research proposals (term x in Equation 1) included members of the Biogen science board and university administrators. Unexpectedly, administrators at American universities were more inclined to veto projects than were administrators at Swiss universities. Conceptually, Swiss universities were apparently more deeply embedded in coordinated networks of industrial production than were their American counterparts (cf. S. Breznitz 2014).

In light of the Biogen story, the question becomes one of how to leverage low-powered incentives for innovative purposes while guarding against moral hazard that undermines innovation. In the Biogen case, the vertical dilemmas problem —in which subordinates exploit information asymmetries for individual gain at the firm's expense— was avoided by virtue of Biogen's non-hierarchical corporate structure. Owing to the fact that Biogen was a start up, each of the founding scientists was a manager, as opposed to a subordinate. The horizontal dilemmas problem —in which team members free-ride on the efforts of their colleagues— was apparently allayed by norms of trust and reciprocity within a regime of tightly knit professionals (cf. Miller & Whitford 2016).

Due to the existence of multiple equilibria, there are no hard and fast solutions to these managerial dilemmas. Rather, cooperation is fragile: it must be inspired when information asymmetries are great (Miller 1992: 232). Experiments with socialism attest to the fact that fantastic achievements are possible, even when incentives are low-powered, if people are motivated by norms of cooperation. The same experiments make plain the deleterious moral hazard implications of purely low-powered incentives when norms begin to erode. The solution advanced by asymmetric growth theorists is to build in high-powered incentives wherever possible. As Acemoglu, Robinson and Verdier acknowledge, realizing the benefits of both low-powered and high-powered incentives entails mixed strategies when deciding on whether to implement "cut-throat" or "cuddly" institutions (2017: 1264).

At the societal level, mixed strategies of the sort just described have been attributed to successful industrialization in East Asia, where networks of horizontally-integrated firms (e.g., keiretsu, chaebol and guanxi qiye) were made to compete against one another for domestic and international markets (Aoki et al. 1997; Wade 1990). Likewise, competition among clusters of cooperating firms has been attributed to competitiveness at the industry level, even in countries like Italy where national-level institutions are not considered to be especially conducive to economic performance (Porter 1990).

Still, quantitative analysis found liberal institutions to be most amenable to radical innovation. While greater incidence of innovation in liberal countries may be due to higher-powered incentives, liberal economies are amply supported by public goods and are thus not strictly market-based. The Biogen case study also revealed that, insofar as university policy toward commercial research is concerned, American institutions can be less conducive to innovation than Swiss institutions. As argued by Gordon Tullock, American institutions may be more vulnerable to rent-seeking on the part of anti-innovation incumbent majority interests than Swiss institutions, the latter of which make greater use of more representative decision rules (2005: 77-79). By their own admission, proponents of "pure science" do not consider adding economic value to society to be part of their craft. According to the pure science paradigm, commercial research in university laboratories is something to be resisted, and resisted it was at Harvard and MIT. By contrast, there was apparently greater appetite for coordination between business and universities in Switzerland.

While frictions associated with labour and shareholder representation at the peak bargaining level have been hypothesized to deter radical innovation in coordinated economies by preventing incumbent firms from reallocating factors of production, the fact that incumbent firms in liberal countries may more easily engage in protectionist lobbying in order to delay creative destruction might even the score. Indeed, although the United States dominates in terms of pharmaceutical patents filed, the number of patents filed per capita is considerably higher in Switzerland (0.14 patents per thousand compared to 0.07). Switzerland and Sweden also out-rank the US on the Global Innovation Index devised by the World Intellectual Property Organization (WIPO 2021).

The previous point speaks to pathologies associated with too much reliance on "cut-throat" liberal-majoritarian institutions, per Streeck's (1997) beneficial constraints thesis. We have seen evidence of institutional correctives to such pathologies at the case level with reference to low-powered incentives, public goods and consensus decisionmaking at Biogen. At the aggregate level, fuzzy-set analysis identified Irish and Westminster institutional configurations as more conducive to innovation than the more market-oriented US configuration (see consistency scores in Tables 1 and 2). Although the last point may be interpreted as quantitative support for the beneficial constraints thesis, it should be kept in mind that the already tenuous significance of quantitative findings diminishes further when US cases are removed from the sample.

Figure 12 depicts the observed relationship between institutions and the two measures of innovation employed in this study. Clearly, the observed relationship does not approximate any of the three hypothesized patterns depicted in Figure 2. While asymmetric growth and varieties of capitalism theory accurately predict market-based institutions to correspond with the global maximum at the market-based pole of the institutional axis, local maxima part way along the institutional continuum are anomalous according to these perspectives. Inversely, while beneficial constraints theory predicts local maxima part way along the institutional axis, it does not anticipate maxima at the poles of the continuum. Granted, reversion to dichotomous LME-CME institutional measures would rescue varieties of capitalism theory from falsification, as values for Japan, South Korea and Switzerland would be relegated to the right pole on the institutional axis, thereby producing the hypothesized V-shaped pattern.

More problematic for varieties of capitalism theory is the fact that the analyses yielded little evidence that coordinated economies excel at incremental innovation. While network analysis suggested there might be a tendency for coordinated economies to inherit intellectual content from liberal economies, survival analysis of whether patent relevance varies systematically across liberal and coordinated economies produced a null result. The substantive implication is that patents from coordinated economies do not systematically exhibit diminishing returns considered to coincide with incremental innovation, at least insofar as pharmaceutical patents are concerned (Acemoglu et al. 2020: 2). Operationalizing incremental innovation as bigram and trigram radicality scores did not produce the expected result, either (see supplement).

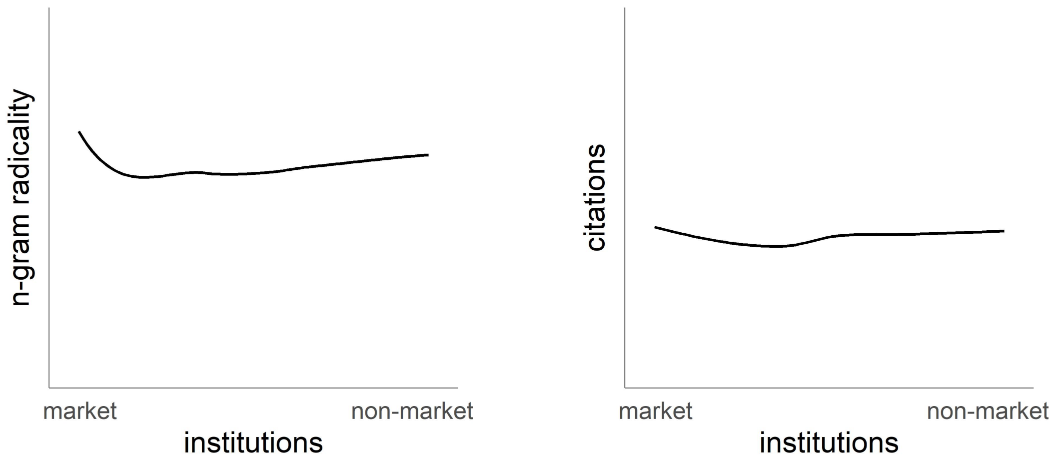

Figure 12: Observed relationship between institutions and innovation

Lines fit with a least squares loess function through data points for the 1960-2020 period. Horizontal axis values calculated by summing institutional indices from Witt and Jackson (2016). The observed relationship does not closely approximate any of the predicted relationships depicted in Figure 2. The asymmetric growth thesis predicts a downward sloping line from left to right; varieties of capitalism predicts a V-shaped pattern; beneficial constraints theory predicts an M-shaped pattern. Local maxima at the right, left and middle suggest that all three theories may be partly correct.

In terms of theoretical synthesis, a fruitful avenue would entail efforts to better delineate between pro-growth and anti-growth institutions. As is well known, freedom to impose externalities and engage in anti-social rent-seeking is not conducive to economic growth (Acemoglu & Robinson 2013; North 1990). Care must therefore be taken to be clear about what we mean when we identify systems as liberal and market-based. From a political theory perspective, no liberal theorist has ever advocated for the freedom to haphazardly impose negative externalities onto others. On the contrary, most acknowledge the possibility of market failure. Likewise, most economists recognize that markets need states (Lipsey & Ragin 2001). Empirically, no political economy has ever exhibited all the characteristics of a truly liberal society (Sen 2017). Moreover, although large multi-divisional organizations play a smaller role in the economy than they once did, contemporary capitalism continues to be characterized ample non-market coordination, even in the most market-oriented countries (Langlois 2003; Simon 1991; Teece 2009).

5. Conclusion

Research on the institutional determinants of innovation has produced many interesting insights, if not definitive answers. The findings of this study speak to the complexity of the puzzle. While there is some evidence that liberal institutions are most conducive to radical innovation, the relationship is tenuous. Contrary to the predictions of asymmetric growth theory, radical innovation is frequent in institutional environments characterized by ample social protection and low-powered incentives. Moreover, consistent with the varieties of capitalism and beneficial constraints theses, non-market institutions may facilitate innovation that would otherwise not be forthcoming by providing public goods, network complementarities and otherwise shielding inventors from excessive risk. However, contrary to the predictions of varieties of capitalism theorists, there is little evidence to suggest that coordinated economies excel at incremental innovation, at least insofar as pharmaceutical patents are concerned.[6] Rather, case analysis of Charles Weissmann's patent on leukocyte interferons revealed that radical innovation is possible even in coordinated economies. Thus, while it may be true that the pace of technological progress would not be sustained if every country were to adopt Scandinavian-style institutions, it appears little would be lost if all countries were to converge on the Swiss model.

The tentativeness of these findings must be stressed, as the research program continues to suffer from a number of limitations. Given the surprisingly weak correlation between citation-based and text-based measures of innovation, it is prudent to devise best practices for extrapolating intellectual content from patent texts. Along these lines, future research should combine textual corpora from the USPTO, the European Patent Office (EPO) and national patent databases. However, for the time being at least, limitations of computing power rule out sophisticated language-based analysis of exceedingly large datasets, which will necessitate sampling on a limited number of technological domains for the foreseeable future (cf. Younge & Kuhn 2016). Yet, even if the entire intellectual corpus was available, results may nevertheless be biased due to the fact that USPTO and EPO patents are in English and English-speaking countries are liberal. Robustness checks should be conducted on non-English patent databases if and when these data become available.

Notwithstanding computational limitations, tremendous opportunities exist in the realm of natural language processing. In theory, part-of-speech tagging and latent semantic analysis could become so well-developed that artificially-intelligent beings become capable of understanding patent texts with a level of sophistication sufficient to engineer inventions. Of course, such intelligent algorithms are not necessary for research purposes, but the possibilities on the horizon speak for themselves. In the short-term, topic modelling is the next logical extension of the text-based method applied in this paper. Topic models utilize either supervised or unsupervised machine learning techniques to derive substance (i.e., topics) from text (Blei et al. 2003; Roberts et al. 2016). Sarah Kaplan and Keyvan Vakili have had some success using topic models to

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[6] It is arguable that pharmaceuticals constitute a radically-innovative industry. Survival analysis of patents belonging to other industries may yield different results regarding variable probability of radical and incremental innovation across liberal and coordinated economies.

analyze patent texts, although their analysis was based only on patent abstracts (2015: 1441).

Regarding substantive extensions, analysis of a wider range of technological domains is obviously required, including (but going beyond) those identified in prior studies of the relationship between institutions, innovation and product exports (e.g., P. Hall & Soskice 2001; Schneider et al. 2010). Because other industries may be better-suited to alternative measures of innovation (related to capacity for commercialization, for instance), it will be necessary to devise such measures. Regarding causal mechanisms, more case-level investigation of data points would go a long way toward revealing which of the causal mechanisms discussed in the section on microfoundations is most effectual in terms of promoting innovation: high-powered incentives, cost externalization ("socialization of risk"), or capacity for collective action. Methodologically, Bayesian process tracing could be used to generate hard measures of the relative performance of inertia and collective action explanations (Bennett 2015).

Fortunately, the architects of the three theories compared in this paper have proven both willing and able to entertain diverse perspectives and incorporate foreign insights into their models (cf. Acemoglu 2003; Hope & Soskice 2016; Iversen & Soskice 2009). An objective of this essay has been to highlight synergies between perspectives and identify empirical questions to be addressed. Further research is needed at all levels of analysis to arrive at robust estimates of the relationship between institutions, innovation and equitable growth, the latter of which is concerned with capturing as much value as possible at the local level (D. Breznitz 2021). While the analysis herein suggests that liberal countries would probably not experience an innovation deficit if they were to adopt greater social protection, best practices for institutional design and optimal level of social protection remain open questions.

Acemoglu, D. (2001). Inefficient redistribution. *American Political Science Review*, *95*(03), 649–661.

Acemoglu, D. (2003). Cross-country inequality trends. *The Economic Journal*, *113*(485), F121–F149.

Acemoglu, D., Akcigit, U., & Celik, M. A. (2020). *Radical and incremental innovation: The roles of firms, managers and innovators*. National Bureau of Economic Research.

Acemoglu, D., & Robinson, J. A. (2015). The rise and decline of general laws of capitalism. *Journal of Economic Perspectives*, *29*(1), 3–28.

Acemoglu, D., Robinson, J. A., & Verdier, T. (2012). *Can't we all be more like Scandinavians? Asymmetric growth and institutions in an interdependent world*. National Bureau of Economic Research.

Acemoglu, D., Robinson, J. A., & Verdier, T. (2017). Asymmetric growth and institutions in an interdependent world. *Journal of Political Economy*, *125*(5), 1245–1305.

Acemoglu, Daron., & Robinson, J. (2013). *Why nations fail: The origins of power, prosperity and poverty*. Crown Publishers.

Adams, D. (2011). Oral history interview with Daniel Adams. Life Sciences Foundation.

Aghion, P., & Howitt, P. (1998). *Endogenous growth theory*. MIT Press.

Akkermans, D., Castaldi, C., & Los, B. (2009). Do 'liberal market economies' really innovate more radically than 'coordinated market economies'? *Research Policy*, *38*(1), 181–191.

Allen, M., & Aldred, M. (2009). Varieties of capitalism, varieties of innovation? A comparison of old and new EU member states. *Journal of Contemporary European Research*, *5*(4), 581–96.

Amable, B. (2003). *The diversity of modern capitalism*. Oxford University Press.

Aoki, M. (2000). *Information, corporate governance, and institutional diversity: Competitiveness in Japan, the USA, and the transitional economies*. Oxford University Press.

Aoki, M., Kim, H., & Okuno-Fujiwara, M. (Eds.). (1997). *The role of government in East Asian economic development*. Oxford University Press.

Arts, S., Cassiman, B., & Gomez, J. C. (2018). Text matching to measure patent similarity. *Strategic Management Journal*, *39*(1), 62–84.

Arts, S., Hou, J., & Gomez, J. C. (2020). Natural language processing to identify the creation and impact of new technologies in patent text: Code, data, and new measures. *Research Policy*, *50*: 1–13.

Arrow, K. J. (1962). Economic welfare and the allocation of resources for invention. In National Bureau for Economic Research (Ed.), *Rate and direction of economic activity* (pp. 609–626). Princeton University Press.

Axelrod, R. M. (1984). *The evolution of cooperation*. Basic Books.

Baumgartner, F., Green-Pedersen, C., Jones, B. D., Breunig, C., Walgrave, S., Nuytemans, M., & Mortensen, P. B. (2009). Punctuated equilibrium in comparative perspective. *American Journal of Political Science*, *53*(3), 603–620.

Bénabou, R. (1996). Inequality and growth. *NBER Macroeconomics Annual*, *11*, 11–74.

Bennett, A. (2015). Disciplining our conjectures: Systematizing process tracing with Bayesian analysis. In A. Bennett & J. T. Checkel (Eds.), *Process tracing: From metaphor to analytic tool* (pp. 276–298). Cambridge University Press.

Berg, A., Ostry, J. D., Tsangarides, C. G., & Yakhshilikov, Y. (2018). Redistribution, inequality, and growth: New evidence. *Journal of Economic Growth*, *23*(3), 259–305.

Bergek, A., & Norrman, C. (2008). Incubator best practice: A framework. *Technovation*, *28*(1), 20–28.

Birchfield, V., & Crepaz, M. (1998). The impact of constitutional structures and collective and competitive veto points on income inequality in industrialized democracies. *European Journal of Political Research*, *34*(2), 175–200.

Black, D. (1958). *The theory of committees and elections*. Cambridge University Press.

Blei, D. M., Ng, A. Y., & Jordan, M. I. (2003). Latent dirichlet allocation. *Journal of Machine Learning Research*, *3*(1), 993–1022.

Block, F. (2008). Swimming against the current: The rise of a hidden developmental state in the United States. *Politics & Society*, *36*(2), 169–206.

Block, F., & Keller, M. R. (2011). *State of innovation: The U.S. Government's role in technology development*. Paradigm Publishers.

Blyth, M. (2002). *Great transformations: Economic ideas and institutional change in the twentieth century*. Cambridge University Press.
Boyer, R. (2004). New growth regimes, but still institutional diversity. *Socio-Economic Review*, *2*(1), 1–32.
Boyer, R. (2005). How and why capitalisms differ. *Economy and Society*, *34*(4), 509–557.
Brady, D., Huber, E., & Stephens, J. D. (2020). Comparative welfare states data set. https://www.lisdatacenter.org/news-and-events/comparative-welfare-states-dataset-2020/
Breznitz, D. (2007). *Innovation and the state: Political choice and strategies for growth in Israel, Taiwan, and Ireland*. Yale University Press.
Breznitz, D. (2021). *Innovation in real places: Strategies for prosperity in an unforgiving world*. Oxford University Press.
Breznitz, S. (2014). *The fountain of knowledge: The role of universities in economic development*. Stanford Business Books.
Buchanan, J., & Tullock, G. (1962). *The calculus of consent: Logical foundations of constitutional democracy*. University of Michigan Press.
Campbell, J. L., Hollingsworth, J. R., & Lindberg, L. N. (Eds.). (1991). *Governance of the American economy*. Cambridge University Press.
Cawson, A. (1985). Varieties of corporatism: The importance of the meso-level of interest intermediation. In A. Cawson (Ed.), *Organized interests and the state: Studies in meso-corporatism* (pp. 1–21). Sage.
Chandler, A. D. (1990). *Scale and scope: The dynamics of industrial capitalism*. Belknap Press.
Checkel, J. T., & Bennett, A. (Eds.). (2015). *Process tracing: From metaphor to analytic tool*. Cambridge University Press.
Coleman, J. S. (1990). *Foundations of social theory*. Harvard University Press.
Conteh, C. (2013). *Policy governance in multi-level systems: Economic development and policy implementation in Canada*. McGill-Queen's University Press.
Criscuolo, P., & Verspagen, B. (2008). Does it matter where patent citations come from? Inventor vs. examiner citations in European patents. *Research Policy*, *37*(10), 1892–1908.
Crouch, C. (2005). *Capitalist diversity and change: Recombinant governance and institutional entrepreneurs*. Oxford University Press.
Delsol, J.-P., Lecaussin, N., & Martin, E. (Eds.). (2017). *Anti-Piketty: Capital for the 21st century*. Cato Institute.
Dick, B., & Jones, M. (2017). The commercialization of molecular biology: Walter Gilbert and the Biogen startup. *History and Technology*, *33*(1), 126–151.
Doern, B., & Tomlin, B. (1996). Trade-industrial policy. In B. Doern, L. Pal, & B. Tomlin (Eds.), *Border crossings: Internationalization and Canadian public policy* (pp. 165–185). Oxford University Press.
Duşa, A., & et al. (2013). QCA: A package for qualitative comparative analysis. *The R Journal*, *5*(1), 87-97.
Etzkowitz, H., & Leydesdorff, L. (1996). Emergence of a triple helix of university-industry-government relations. *Science and Public Policy*, *23*, 279–286.
Evans, P. B. (1995). *Embedded autonomy: States and industrial transformation*. Princeton University Press.

Galbraith, J. K. (1972). *The new industrial state* (2nd ed.). Mentor.
Gereffi, G., Humphrey, J., & Sturgeon, T. (2005). The governance of global value chains. *Review of International Political Economy, 12*(1), 78–104.
Gilbert, R. J., & Newbery, D. M. G. (1982). Preemptive patenting and the persistence of monopoly. *The American Economic Review*, *72*(3), 514–526.
Gilbert W. (2012). Oral history interview with Walter Gilbert. Life Sciences Foundation.
Goracinova, E., Warrian, P., & Wolfe, D. A. (2016). Challenges of coordination: Automotive innovation in the Ontario supply chain in comparative context. *Canadian Public Policy*, *43*(S1), S90–S102.
Hacker, J. S., & Pierson, P. (2010). Winner-take-all politics: Public policy, political organization, and the precipitous rise of top incomes in the United States. *Politics & Society*, *38*(2), 152–204.
Haddow, R. (2015). *Comparing Quebec and Ontario: Political economy and public policy at the turn of the millennium*. University of Toronto Press.
Hair, J. F., Anderson, R. E., Tatham, R. L., & Black, W. C. (1995). *Multivariate Data Analysis* (4th ed.). Prentice Hall.
Hall, B. H., Jaffe, A. B., & Trajtenberg, M. (2001). *The NBER patent citation data file: Lessons, insights and methodological tools*. National Bureau of Economic Research.
Hall, P. A. (1986). *Governing the economy: The politics of state intervention in Britain and France*. Polity Press.
Hall, P. A., & Gingerich, D. (2009). Varieties of capitalism and institutional complementarities in the political economy: An empirical analysis. *British Journal of Political Science*, *39*(3), 449–482.
Hall, P. A., & Soskice, D. W. (2001). An introduction to the varieties of capitalism. In P. A. Hall & D. W. Soskice (Eds.), *Varieties of capitalism: The institutional foundations of comparative advantage* (pp. 1–68). Oxford University Press.
Häusermann, S., & Schwander, H. (2012). Varieties of dualization? Labor market segmentation and insider-outsider divides across regimes. In P. Emmenegger, S. Häusermann, B. Palier, & M. Seeleib-Kaiser (Eds.), *The age of dualization: The changing face of inequality in deindustrializing societies* (pp. 27–47). Oxford University Press.
Hemphill, T. A. (2020). The innovation governance dilemma: Alternatives to the precautionary principle. *Technology in Society*, *63*, 1013-81.
Henisz, W. (2000). The institutional environment for economic growth. *Economics & Politics*, *12*(1), 1–31.
Henisz, W. (2017). The political constraint index (POLCON) dataset. https://mgmt.wharton.upenn.edu/faculty/heniszpolcon/polcondataset/
Hira, A. (2007). *An East Asian model for Latin American success: The new path*. Ashgate.
Hölmstrom, B. (1979). Moral hazard and observability. *Bell Journal of Economics*, *10*(1), 74.
Hope, D., & Soskice, D. (2016). Growth models, varieties of capitalism, and macroeconomics. *Politics & Society*, *44*(2), 175–207.
Howse, R., & Chandler, M. (1997). Industrial policy in Canada and the United States. In K. Banting, G. Hoberg, & R. Simeon (Eds.), *Degrees of freedom: Canada and the*

United States in a Changing World (pp. 231–266). McGill-Queen's University Press.
Iversen, T., & Soskice, D. (2009). Distribution and redistribution: The shadow of the nineteenth century. *World Politics*, *61*(3), 438–486.
Jackson, G., & Deeg, R. (2008). Comparing capitalisms: Understanding institutional diversity and its implications for international business. *Journal of International Business Studies*, *39*(4), 540–561.
Jessop, B. (1998). The rise of governance and the risks of failure: The case of economic development. *International Social Science Journal*, *50*(155), 29–45.
Jessop, B. (2011). Rethinking the diversity of capitalism: Varieties of capitalism, variegated capitalism, and the world market. In G. Wood & C. Lane (Eds.), *Capitalist diversity and diversity within capitalism* (pp. 209–237). Routledge.
Jones, B. D., & Bachelor, L. (1993). *The sustaining hand: Community leadership and corporate power* (2nd ed.). University Press of Kansas.
Jones, B. D., & Baumgartner, F. R. (2005). A model of choice for public policy. *Journal of Public Administration Research and Theory*, *15*(3), 325–351.
Jones, B. D., Baumgartner, F. R., Breunig, C., Wlezien, C., Soroka, S., Foucault, M., François, A., Green-Pedersen, C., Koski, C., John, P., Mortensen, P. B., Varone, F., & Walgrave, S. (2009). A general empirical law of public budgets: A comparative analysis. *American Journal of Political Science*, *53*(4), 855–873.
Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica: Journal of the Econometric Society*, 263–291.
Kaplan, D. (2009). *Structural equation modeling: Foundations and extensions*. Sage Publications.
Kaplan, S., & Vakili, K. (2015). The double-edged sword of recombination in breakthrough innovation. *Strategic Management Journal*, *36*(10), 1435–1457.
Kenworthy, L. (2006). Institutional coherence and macroeconomic performance. *Socio-Economic Review*, *4*(1), 69–91.
Kogut, B., & Ragin, C. (2006). Exploring complexity when diversity is limited: Institutional complementarity in theories of rule of law and national systems revisited. *European Management Review*, *3*(1), 44–59.
Koos, S., & Sachweh, P. (2019). The moral economies of market societies: Popular attitudes towards market competition, redistribution and reciprocity in comparative perspective. *Socio-Economic Review*, *17*(4), 793–821.
Korpi, W. (1983). *The democratic class struggle*. Routledge.
Kuhn, J. M., & Thompson, N. (2017). *How to measure and draw causal inferences with patent scope* (SSRN Scholarly Paper ID 2977273). Social Science Research Network. https://doi.org/10.2139/ssrn.2977273
Kuhn, J. M., Younge, K. A., & Marco, A. C. (2019). *Patent citations re-examined* (SSRN Scholarly Paper ID 2714954; pp. 1–47). Social Science Research Network. https://papers.ssrn.com/abstract=2714954
Kwon, H., Lee, J., Lee, S., & Oh, R. (2020). Knowledge spillovers and patent citations: Trends in geographic localization, 1976–2015. *Economics of Innovation and New Technology*, *early view*, 1–25.
Lafond, F., & Kim, D. (2019). Long-run dynamics of the U.S. patent classification system. *Journal of Evolutionary Economics; Heidelberg*, *29*(2), 631–664.

Langlois, R. N. (2003). The vanishing hand: The changing dynamics of industrial capitalism. *Industrial and Corporate Change*, *12*(2), 351–385.
Le Grand, J. (1991). The theory of government failure. *British Journal of Political Science*, *21*(4), 423–442.
Lester, J. (2018). *Business subsidies in Canada comprehensive estimates for the Government of Canada and the four largest provinces* (11:1; pp. 1–34). University of Calgary School of Public Policy.
Li, G., Lai, R., D'Amour, A., Doolin, D. M., Sun, Y., Torvik, V. I., Yu, A. Z., & Fleming, L. (2014). Disambiguation and co-authorship networks of the U.S. patent inventor database (1975–2010). *Research Policy*, *43*(6), 941–955.
Lieberman, E. (2005). Nested analysis as a mixed-method strategy for comparative research. *American Political Science Review*, *99*(03), 435–452.
Lijphart, A. (2012). *Patterns of democracy: Government forms and performance in thirty-six countries*. Yale University Press.
Lipsey, R. G., & Ragan, C. T. S. (2001). *Microeconomics* (10th ed.). Addison Wesley Longman.
Lundvall, B.-Å. (Ed.). (1992). *National systems of innovation: Towards a theory of innovation and interactive learning*. St. Martin's Press.
Mahoney, J. (2008). Toward a unified theory of causality. *Comparative Political Studies*, *41*(4–5), 412–436.
Martin, C. J., & Swank, D. (2012). *The political construction of business interests: Coordination, growth, and equality*. Cambridge University Press.
Marwell, G., & Oliver, P. (1993). *The critical mass in collective action: A micro-social theory*. Cambridge University Press.
Mazzucato, M. (2013). *The entrepreneurial state: Debunking public vs. private sector myths*. Anthem Press.
Mazzucato, M. (2021). *Mission economy: A moonshot guide to changing capitalism*. Harper Business.
Milgrom, P., & Roberts, J. (1995). Complementarities and fit strategy, structure, and organizational change in manufacturing. *Journal of Accounting and Economics*, *19*(2–3), 179–208.
Miller, G. J. (1992). *Managerial dilemmas: The political economy of hierarchy*. Cambridge University Press.
Miller, G. J., & Whitford, A. B. (2016). *Above politics: Bureaucratic discretion and credible commitment*. Cambridge University Press.
Nelson, R. R. (1959). The simple economics of basic scientific research. *Journal of Political Economy*, *67*(3), 297–306.
Nielsen, L. (2018). What is our real concern with real inequality? *Policy Studies Journal*, *46*(3), 553–572.
North, D. C. (1990). *Institutions, institutional change and economic performance*. Cambridge University Press.
Ornston, D. (2012). *When small states make big leaps*. Cornell University Press.
Ornston, D. (2018). *Good governance gone bad*. Cornell University Press.
Ostrom, E. (1986). An agenda for the study of institutions. *Public Choice*, *48*(1), 3–25.
Ostrom, E. (2005). *Understanding institutional diversity*. Princeton University Press.
Phillips, P. W. B. (2007). *Governing transformative technological innovation: Who's in charge?* Edward Elgar.

Pieters, T. (2005). *Interferon: The science and selling of a miracle drug*. Routledge.
Piketty, T. (2014). *Capital in the twenty-first century*. Belknap Press.
Polanyi, K. (1944). *The great transformation*. Beacon Press.
Porter, M. E. (1990). *The competitive advantage of nations*. Macmillan.
Ragin, C. C. (2000). *Fuzzy-set social science*. University of Chicago Press.
Ragin, C. C. (2006). Set relations in social research: Evaluating their consistency and coverage. *Political Analysis*, *14*(3), 291–310. JSTOR.
Ragin, C. C. (2008). *Redesigning social inquiry*. University of Chicago Press.
Rebelo, S. (1991). Long-run policy analysis and long-run growth. *Journal of Political Economy*, *99*(3), 500–521.
Roberts, M., Stewart, B., & Tingley, D. (2016). Navigating the local modes of big data: The case of topic models. In M. Alvarez R. (Ed.), *Computational social science: Discovery and prediction* (pp. 51–97). Cambridge University Press, New York.
Rodrik, D. (1997). The 'paradoxes' of the successful state. *European Economic Review*, *41*(3), 411–442.
Rodrik, D. (2007). *One economics, many recipes: Globalization, institutions, and economic growth*. Princeton University Press.
Scharpf, F. W. (1997). *Games real actors play: Actor-centered institutionalism in policy research*. Westview Press.
Scharpf, F. W., & Mohr, M. (1994). Efficient self-coordination in policy networks: A simulation study (Working Paper No. 94/1). MPIfG discussion paper. https://www.econstor.eu/handle/10419/43733
Schattschneider, E. E. (1960). *The semisovereign people*. Wadsworth.
Schmidt, V. A. (2009). Putting the political back into political economy by bringing the state back in yet again. *World Politics*, *61*(3), 516–546.
Schneider, M. R., & Paunescu, M. (2012). Changing varieties of capitalism and revealed comparative advantages from 1990 to 2005: A test of the Hall and Soskice claims. *Socio-Economic Review*, *10*(4), 731–753.
Schneider, M. R., Schulze-Bentrop, C., & Paunescu, M. (2010). Mapping the institutional capital of high-tech firms: A fuzzy-set analysis of capitalist variety and export performance. *Journal of International Business Studies*, *41*(2), 246–266.
Sharp, P. (2012). Oral history interview with Phillip A. Sharp. Life Sciences Foundation.
Shepsle, K. A. (2010). *Analyzing politics*. W.W. Norton.
Silverberg, G., & Verspagen, B. (2007). The size distribution of innovations revisited: An application of extreme value statistics to citation and value measures of patent significance. *Journal of Econometrics*, *139*(2), 318–339.
Simon, H. A. (1991). Organizations and markets. *The Journal of Economic Perspectives*, *5*(2), 25–44.
Soskice, D. (1997). German technology policy, innovation, and national institutional frameworks. *Industry and Innovation*, *4*(1), 75–96.
Sternitzke, C. (2010). Knowledge sources, patent protection, and commercialization of pharmaceutical innovations. *Research Policy, 39*(6), 810–821.
Streeck, W. (1997). Beneficial constraints: On the economic limits of rational voluntarism. In J. Hollingsworth & R. Boyer (Eds.), *Contemporary Capitalism: The Embeddedness of Institutions* (pp. 197–219). Cambridge University Press.

Sussex, J., & Marchant, N. (Eds.). (1999). *Risk and return in the pharmaceutical industry*. Office of Health Economics.
Taylor, M. Z. (2004). Empirical evidence against varieties of capitalism's theory of technological innovation. *International Organization*, *58*(3), 601–631.
Taylor, M. Z. (2016). *The Politics of Innovation: Why Some Countries Are Better Than Others at Science and Technology*. Oxford University Press.
Teece, D. J. (2009). *Dynamic capabilities and strategic management organizing for innovation and growth*. Oxford University Press.
Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal*, *18*(7), 509–533.
Thelen, K. Ann. (2014). *Varieties of liberalization and the new politics of social solidarity*. Cambridge University Press.
Trajtenberg, M., Henderson, R., & Jaffe, A. (1997). University versus corporate patents: A window on the basicness of invention. *Economics of Innovation and New Technology*, *5*(1), 19–50.
Tsebelis, George. (2002). *Veto players: How political institutions work*. Princeton University Press.
Tullock, G. (2005). *The rent-seeking society*. Liberty Fund.
USPTO. (2021). *USPTO full text and image database*. http://patft.uspto.gov/netahtml/PTO/search-bool.html
Visser, J. (2019). *ICTWSS database, version 6.1*. Institute for Advanced Labour Studies. https://www.ictwss.org/downloads
Vogel, D. (1987). Government-industry relations in the United States: An overview. In S. Wilks & M. Wright (Eds.), *Comparative government-industry relations* (pp. 91–116). Clarendon.
Wade, R. (1990). *Governing the market: Economic theory and the role of government in East Asian industrialization*. Princeton University Press.
Weiss, L. (2014). *America inc.? : Innovation and enterprise in the national security state*. Cornell University Press.
Weissmann, C. (2012). The end of the road. *Prion*, *6*(2), 97–104.
Whitley, R. (2007). *Business systems and organizational capabilities: The institutional structuring of competitive competences*. Oxford University Press.
WIPO. (2021). *Global innovation index 2021* (14th ed.). World Intellectual Property Organization.
Witt, M. A., & Jackson, G. (2016). Varieties of Capitalism and institutional comparative advantage: A test and reinterpretation. *Journal of International Business Studies*, *47*(7), 778–806.
Witt, M. A., Kabbach de Castro, L. R., Amaeshi, K., Mahroum, S., Bohle, D., & Saez, L. (2018). Mapping the business systems of 61 major economies: A taxonomy and implications for varieties of capitalism and business systems research. *Socio-Economic Review*, *16*(1), 5–38.
Wolfe, D. A., & Lucas, M. (Eds.). (2004). *Clusters in a cold climate: Innovation dynamics in a diverse economy*. McGill-Queen's University Press.
Younge, K. A., & Kuhn, J. M. (2016). *Patent-to-patent similarity: A vector space model* (SSRN Scholarly Paper ID 2709238). Social Science Research Network. https://papers.ssrn.com/abstract=2709238