NBER WORKING PAPER SERIES

MAPPING TECHNOLOGICAL TRAJECTORIES:
EVIDENCE FROM TWO CENTURIES OF PATENT DATA

Antonin Bergeaud
Ruveyda Nur Gozen
John Van Reenen

Working Paper 34760
http://www.nber.org/papers/w34760

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
January 2026

We would like to thank the ESRC for funding this research through POID (Programme On Innovation and Diffusion). Philippe Aghion has given us very helpful comments. Frederic Denker and Jacaopo Marini provided great research assistance. The views expressed herein are those of the authors and do not necessarily reflect the views of the National Bureau of Economic Research.

Mapping Technological Trajectories: Evidence from Two Centuries of Patent Data
Antonin Bergeaud, Ruveyda Nur Gozen, and John Van Reenen
NBER Working Paper No. 34760
January 2026
JEL No. O31, O33, O34

ABSTRACT

We introduce a methodology to measure cross-country trends in innovation capability - "technological trajectories" and implement this on a new rich dataset covering patents between 1836 and 2016 across multiple countries. Intuitively, trajectories are revealed by a country's sustained increases in patenting across multiple patent offices. We first describe the data patterns, showing the relative decline of the UK, and the rise first of the US and Germany, and then later of Japan and China. We then econometrically estimate trajectories on (i) the post-1902 period for France, Germany, Japan, the UK and US, and (ii) the post-1960 period for a wider sample of 40 countries. Our trajectories are strongly positively correlated with Total Factor Productivity growth, and also (but less strongly) associated with the growth of labour productivity and capital intensity. We show that future trajectories are predicted by a country's initial levels of R&D, education and defence spending, classic drivers of innovation in modern growth theory.

Antonin Bergeaud
HEC Paris
bergeaud@hec.fr

Ruveyda Nur Gozen
London School of Economics and
Political Science (LSE)
and Cardiff Business School
r.n.gozen@lse.ac.uk

John Van Reenen
London School of Economics and
Political Science (LSE)
Department of Economics
and NBER
j.vanreenen@lse.ac.uk

1 Introduction

Innovation lies at the heart of long-run economic growth, yet measuring the evolving technological prowess of nations remains challenging. Total Factor Productivity (TFP) is the most widely used summary statistic, but it faces formidable conceptual and measurement difficulties, particularly when comparisons span long historical periods across multiple countries. Productivity measures rely on strong assumptions about production technologies, price indices, and factor inputs, all of which become increasingly fragile as one moves further back in time or across institutional settings.

Patent information offers an attractive and widely used complement. Patents provide a direct record of commercialisable invention, contain detailed technical information, and are in principle available for many countries over very long periods. A vast literature has therefore relied on patent data to proxy innovative activity and to trace the evolution of technological change over time (e.g. Petralia et al., 2016; Kogan et al., 2017; Akcigit et al., 2017; Berkes, 2018; Akcigit and Nicholas, 2019; Sarada et al., 2019; Bergeaud and Verluise, 2024a). However, using patents to compare innovation performance across countries and over long horizons poses significant challenges. Patent systems differ across countries, patenting propensities vary across sectors, and the global intellectual property landscape has changed substantially over time. In addition, inventors and firms exhibit a strong tendency to file patents in their home country, reflecting familiarity with domestic legal systems and lower costs. This "home bias" distorts the geographic distribution of patenting and complicates international comparisons. As a result, relatively few studies have used patent data to document technological leadership and catch-up over extended periods and at the global level (De Rassenfosse et al., 2013).

The central idea of this paper is that much of this noise can be filtered out by examining not just who patents but also exploiting information across multiple jurisdictions. The key intuition is to examine a country's inventive performance across multiple foreign patent offices. For example, a surge in patenting by American inventors at the US Patent Office could simply reflect changes in domestic examination standards or legal practices. But if patents by American assignees are simultaneously rising in the UK *and* French patent offices, this is more likely to reflect genuine technological advances originating in the US. This intuition underlies a long tradition in the literature, such as Soete and Wyatt (1983), who emphasized international patenting as a way to disentangle technological performance from idiosyncratic features of national patent systems. More recent work has formalized this insight through the use of patent families and multi-office filings, arguing that inventions protected in multiple jurisdictions are less sensitive to office-specific institutional changes and therefore more comparable across countries (e.g. De Rassenfosse et al., 2013, Dechezleprêtre et al., 2017). International patent families have become a standard tool for identifying high-value inventions and mitigating home bias in cross-country analyses (OECD, 2009, Hall et al., 2010).

Building on this tradition, we propose a methodology for measuring countries' technological trajectories, defined as the (relative) rate of innovation over time.[1] Rather than focusing on a narrow subset of patent families, our approach tracks the evolution of countries' patenting activity across multiple foreign patent offices over long horizons. By doing so, we attempt to isolate the component of innovative activity that is common across different examination systems and therefore more likely to reflect underlying capabilities rather than institutional or procedural changes at any one single office.

To implement this approach, we assemble new historical patent data covering almost two centuries (1986-2016), drawing on filings at the four major patent offices in the US, UK, Germany, and France. For each office, we observe both domestic and foreign assignees, allowing us to construct measures of innovative activity by country of origin that rely exclusively on foreign patenting. We further incorporate controls for evolving home bias and conduct a range of robustness checks to assess the stability of the resulting technological trajectories.

We first describe long-run trends. We show the rapid growth in patenting over time and the increasing internationalisation of all four offices, as reflected in the rising share of foreign patents. We trace the emergence of American technological leadership from the late nineteenth century, accelerating markedly after the Second World War.[2] We also document the rise of Germany in the twentieth century, Japan from the 1960s onward, and the rapid technological expansion of China after 2000, which appears closely linked to its manufacturing capabilities.

We then show that these descriptive patterns are preserved when we implement our econometric methodology to estimate technological trajectories for six major countries over the period 1902-2016. Extending the analysis to a broader sample of 40 countries in the 1960–2016 period, we examine how these trajectories relate to macroeconomic observables. The technological trajectories are strongly correlated with TFP growth,

[1]These trajectories are a measure of the rate of innovation, so are distinct from the other uses of term elsewhere in the literature - e.g. Dosi (1982).

[2]The UK led from the late eighteenth to the mid-nineteenth century due to pioneering advances in textiles, iron, steam power, and machinery (Allen, 2009; Mokyr, 2010; Broadberry and Irwin, 2006). By the end of the nineteenth century, however, the United States had overtaken it, propelled by abundant resources, institutional innovation, and the rise of mass production (Wright, 1990; David and Wright, 1999; Sokoloff, 1992).

while also displaying positive, though weaker, associations with labour productivity growth and capital intensity growth. Finally, we show that future technological trajectories are closely linked to initial levels of R&D, and education and defence investment. This is broadly in line with predictions from modern growth theory.

The contribution of this paper is threefold. First, we introduce a new way of comparing national innovation performance based on foreign patent filings by assignee location. Second, we use this measure to shed light on the relationship between technological leadership and macroeconomic development. Third, we provide a new long-run dataset covering nearly two centuries of patenting activity across the four major patent offices.[3]

The remainder of the paper is organised as follows. Section 2 describes the data. Section 3 presents descriptive evidence. Section 4 outlines the methodology and main results for six countries. Section 5 extends the analysis to 40 countries and examines macroeconomic correlates and Section 6 concludes.

2 Data

Data details are in Appendix A, but we sketch some salient aspects here. We use several data sources to construct technological trajectories and economic outcomes at the country level. Our fundamental source of multinational data is PatentCity (Bergeaud and Verluise, 2024b) which provides patents and location information from the late 19^{th} century through 2021. All sources have assignee country, so we use this as out main location indicator, but also complement with other locational measures (e.g. inventor).

PatentCity. PatentCity is a multinational database providing long-term individual-level patent data for several countries. It covers all patents granted in patent offices in the United States from 1836, the United Kingdom from 1894, Germany from 1877, and France from 1903. We use the location of assignees as well as information on inventor country of origin, and citizenship.[4] We complement PatentCity with a novel private dataset of British patents[5] between 1855 and 1899 that has inventor and assignee countries. Since citizenship information was provided for patents in the UK until the

[3]The Appendix discusses the additional use of English patent data from 1617-1899.

[4]See Appendix A.1 details on the use of assignee, inventor, and citizenship.

[5]We thank Davide Coluccia and Gaia Dossi for sharing their data with us. For details of the data, see Coluccia and Dossi (2025). Additionally, a recent work by Berkes et al. (2026) provides all British patents from 1617 to 1899 publicly.

mid-20^{th} century, we use citizenship in case no assignee or inventor information is available on patent files.[6]

PATSTAT. After 1978, the number of local patents sharply declined due to the establishment of the European Patent Office (EPO). The EPO introduced a unified patent application process, enabling broader protection of inventions across designated countries. Applicants mostly prefer the EPO because granted patents can be enforced and protected in multiple designated countries.[7] We utilize the data files from the 2023 Spring release. To avoid double-counting, we fractionally assign each patent across countries when there are multiple assignees (e.g., if there are two assignees, we count it as 0.5 for each country).[8] For the descriptives below, we then compute each country's share among total patents in a restricted sample of five major economies: the United States, the United Kingdom, France, Germany, and Japan.

Macro Data. To look at macroeconomic performance, we first use the Long Term Productivity Database by Bergeaud et al. (2016) for annual estimates of labour productivity, and capital per hour worked. We obtain tertiary schooling attainment data from (Barro and Lee, 2013), the human capital index and total factor productivity (TFP) from Penn World Tables database. We use national defense expenditure per capita from Cross-National Time Series Database (CNTS) and real GDP per capita from Maddison Project Database. We also use inequality measures from World Inequality Database (WID). We use the OECD database to obtain the number of researchers, and R&D investments per capita. For the industry shares (focusing on manufacturing), we use data by Madsen (2024)[9] and for manufacturing shares in China, we use the data from National Bureau of Statistics of China. Data availability varies by country and year, so we focus our analysis of the relationship between our technological trajectories and macroeconomic indicators to the years between 1960 and 2016.

[6] In all our analyses, we combine the East and West Germany patents as "German" to deal with the post War split and reunification.

[7] See Appendix A.2 for details on designation country classification.

[8] International patent collaborations increase significantly after the 1970s due to globalization, but we rarely observe cross-country assignee patterns in 17^{th}, 18^{th}, and early 19^{th} century records.

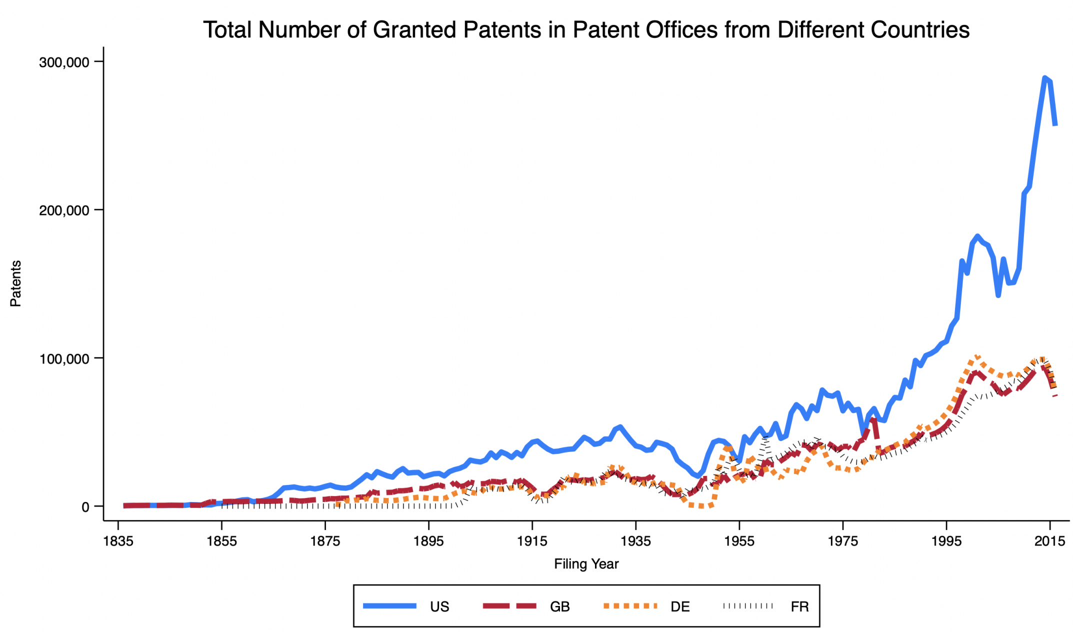
[9] We thank Jakob Madsen for sharing the data with us.

3 Descriptive Analysis

3.1 The growth of aggregate patenting, 1836-2016

We first analyze general patents trends from 1836 through 2016. We begin in 1836 as it is the first year for which reliable patent data are available at the USPTO and end in 2016, to avoid censoring due to lags between grant and application date.[10] Figure I presents the total number of granted patents at the four main patent offices in the UK, US, Germany and France. Although patents have grown in all offices, USPTO patents rose most strongly, taking off after the Civil War in the 1860s.

FIGURE I. Trends in Innovations



Notes: This Figure shows the total number of granted patents for four national patent offices. Years covered are 1836-2016 for the USPTO, 1855-2016 for the UK patent office, 1878-2016 for the German patent office and 1903-2016 for French patent office. See text for details.

3.2 The Globalization of Innovation

The rising number of patents at a given office does not necessarily imply that domestic inventors were the sole drivers of this growth. In the aftermath of World War II,

[10]Data availability means we can only start using data from the UK patent office in 1855 (and 1878 and 1902 for the German and French Offices respectively). We show some patents trends from 1617 onwards for the UK. See Appendix for more details.

with the revolution in information technologies and advancements in transportation and communication methods in the 1970s, innovation collaborations and activity in foreign patent offices increased.

We illustrate this in Figure II, which plots the fraction of patents granted to a foreign assignee in each of the four patent offices. This has risen substantially over two centuries, especially after the end of World War II. Indeed, prior to 1945, foreign shares were falling in the French and German patent offices and static after a rise in the in the 19$^{\text{th}}$ century in the UK and US offices.

The share of patents held by foreign assignees has been consistently lower in the USPTO than in other patent offices. Even at the end of our sample period, only about 30% of patents are foreign in the US compared to about 60% in Germany, 70% in France and 90% in the UK.[11] Kortum and Lerner (1999) examine the surge in U.S. patenting during the 1980s and 1990s and argue that the globalization of technology markets and patent systems encouraged firms to protect their innovations abroad. However, they find that the main driver of rising U.S. patenting was improved research productivity, not a sharp increase in foreign filings. These findings align with our results: while international patenting became more widespread over time, domestic innovative activity remained comparatively stronger in the US than in European economies.

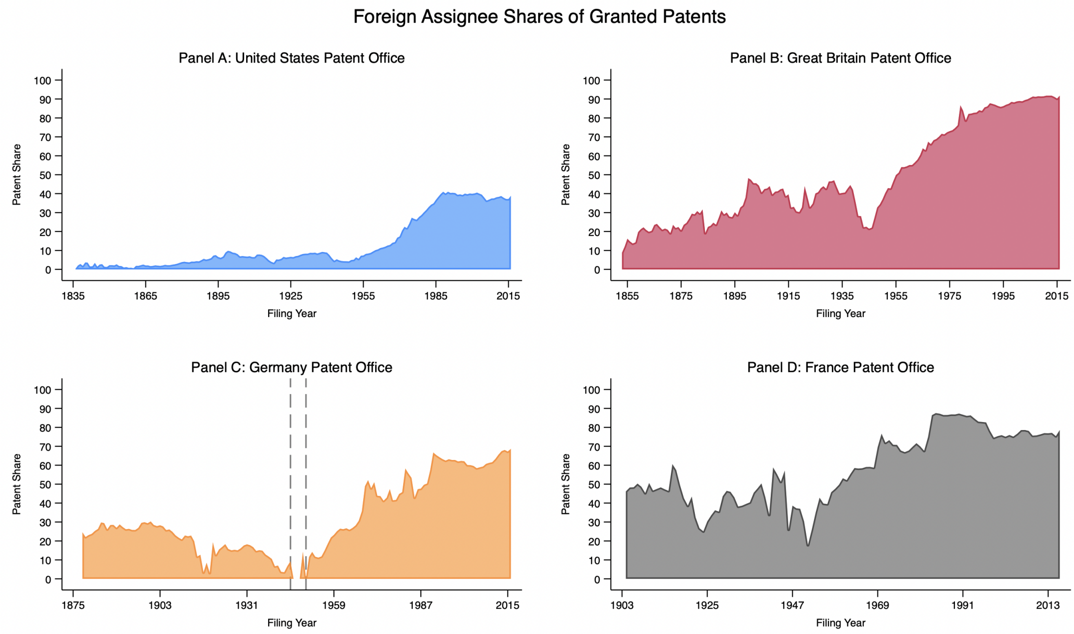
3.3 The Rise of the US and Germany after the Second Industrial Revolution and World War II

We next calculate the share of patents assigned to a given country in foreign patent offices (to mitigate home bias). For example, to assess US innovation relative to France, we measure the American share of assignees compared to the French share in the UK patent office. Foreign patent offices provide a more neutral ground for comparing cross-country technological progress. This is the intuitive measure we will formalise in the econometric framework in the next section. Figure III shows the foreign assignee shares in each patent office by decade.[12] We focus exclusively on non-domestic applicants to highlight international technological activity over time (the complement of Figure II).

[11] The high share of foreign assignees in European countries may be inflated by the inclusion of EPO publications, which is counted only when they designate the country.

[12] We do this to smooth the series. Figure A2 in the Appendix shows technological trajectories by year.

FIGURE II. Globalization and Trends in Innovations

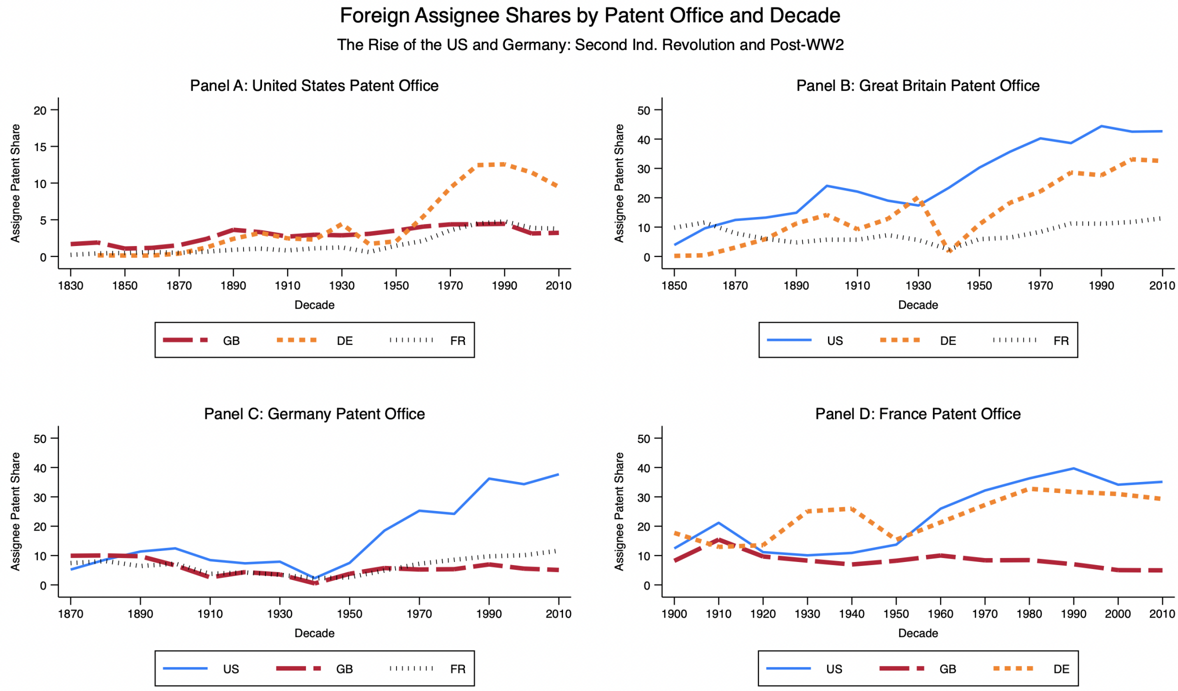


Notes: This panel shows the globalization trend for each office over time. We calculate each country's foreign share of patents based on the assignee countries. The period in this graph is 1836-2016 for the US, 1855-2016 for the UK, 1878-2016 for Germany (the dashed lines represent WW2), and 1903-2016 for France.

We highlight three findings in Figure III. First, the rise of US innovation stands out (this is the solid blue line). There is suggestive evidence of a small take-off of US innovation 1870-1910 (especially in Panels B, the UK office) coinciding with the "Second Industrial Revolution". But the big transformation is during and after WW2 where Panels B-D (the three European countries' offices) show the US share rising from 10%-20% in the 1930s to around 40% by the 2010s. The fact that this is evident in all three European countries indicates that this is likely to be real, rather than an institutional idiosyncrasy of an individual patent office.

Second, we also see Germany's rise to prominence (the dashed orange line in Figure III). During the 19th century and early 20th century, German innovation seemed to grow as fast as that of America. Naudé and Nagler (2021) document the historical trajectory of German innovation, emphasizing the rapid industrialization and technological development that followed Germany's unification in 1871. Their analysis highlights how educational and research reforms initiated by Frederick the Great and Wilhelm von Humboldt played a critical role in building the modern research university system, fostering scientific inquiry and technical expertise. There was also a postwar surge in German patents. Germany outstrips France and the UK in the

FIGURE III. Country shares of non-domestic patents in Foreign Patent Offices



Notes: The share of assignees from named country as a share of all non-domestic applicants. For example, the UK has about a 4% share of all non-US assigned patents in the USPTO in 1990. Each panel is from a different patent office. Decadal averages are shown (e.g. 1910 is the 1906-2005 average). See text for more details.

USPTO in Panel A, for example. And Germany shares grow faster than those of the UK in the French patent office, and faster than those of France in the UK patent office.

Thirdly, we see the relative decline of the UK. British-originated innovations initially represented one of the largest foreign groups at the USPTO, maintaining a strong presence until the end of the 19th century. However, UK innovators gradually lost their relative position as the US and Germany gained momentum. The French share in the USPTO was much less than the UK in 1945, but had caught up by the end of the period. In the German patent office, French and British patents were similar until 1970, after which France started to capture a larger share than the UK.

3.4 The East Asian Innovation Miracle: The Rise of Japan and China

The post–World War II period also saw a rapid surge in innovation from several Asian countries. We bring this out in Figure IV which has the the same conceptual analysis of shares as Figure III. In particular, we show the foreign shares of Japan and China in our four offices (with the US as a benchmark - identical to Figure III). [13]

Japan stands out with a substantial rise in its share of innovations and became the leading source of foreign USPTO patenting. In European patent offices, Japan's rise in innovation is also significant, catching up with Germany in the UK and French patent offices during the 1970s, and narrowing the gap with the US.

Bergeaud et al. (2015) show that Japan rapidly caught up in productivity during this period. Acemoglu et al. (2006) further argue that Japan's postwar growth was driven by high investment rates, the breakup of industrial monopolies, democratized political institutions, government subsidies, and relatively protected domestic markets.[14] After the bursting of the real estate bubble in the laste 1980s, Japan's relative economic performance declined. Our results also indicate a stagnation in Japan's share of innovation in foreign markets after 1990.

China's economic and technological take-off has become a defining feature of the 21st century. Figure IV illustrates the sharp rise in China's activity across foreign patent offices, especially after 2010. Chinese assignees surpassed those from the UK and narrowed the gap with Germany and France. Some studies raise concerns about the quality of this innovation and argue that Chinese research remains heavily reliant on foreign scientific networks and is less embedded in high-impact knowledge production (Aghion et al., 2024; Qiu et al., 2025).[15] Nonetheless, more recent evidence points to improvement. For example, Baruffaldi et al. (2020) show that China's share of AI-related patents increased more than sixfold since the mid-2000s. Similarly, Bergeaud and Verluise (2022) find that China's top 10% most-cited patents are converging toward levels seen in Europe and Japan, indicating a growing presence at the global technology frontier.

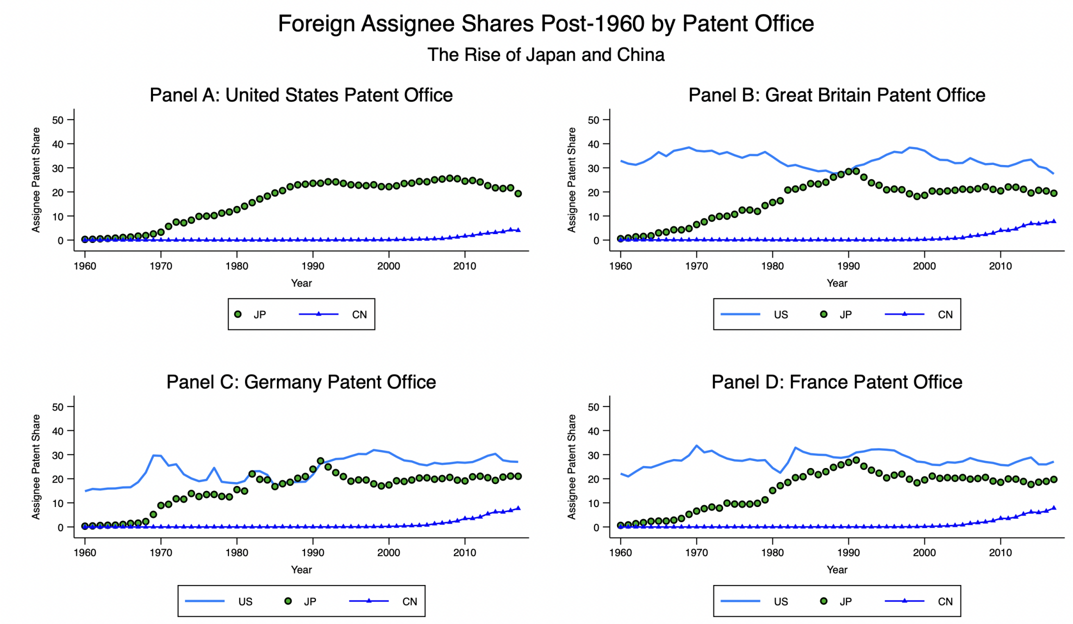
Overall, the rapid growth in Chinese patenting across foreign offices suggests a significant expansion of its international technological footprint. We examine this take-off in more detail in the next section, finding it is partly driven by large-scale investments in manufacturing.

[13] Recall that these two countries were in the denominator of the foreign shares in Figure III.

[14] Some studies suggest that Japan's catch up process with the UK and advanced economies began even earlier. Broadberry et al. (2015) argue that Japan had already surpassed the UK as a major exporter of manufactured goods before World War II, partly by keeping real wage growth below productivity growth to maintain a unit labour cost advantage. However, Broadberry (1994) note that Japan's technological advancement relied more on cost efficiency and craft-based methods than on mass production, which limited its TFP gains compared to the United States.

[15] Some studies note that many Chinese patents originate from design or utility models rather than from frontier technological breakthroughs (Santacreu and Zhu, 2018).

FIGURE IV. Country shares of non-domestic patents in Foreign Patent Offices: Japan and China



Notes: Same analysis as Figure III, except we highlight the Japanese and Chinese share instead of those of the European countries and data is from 1960 onwards. The share of assignees from named country as a share of all non-domestic applicants. Each panel is from a different patent office. Decadal averages are shown (e.g. 1910 is the 1906-2005 average). See text for details.

4 Empirical Analysis

4.1 Methodology

Motivated by these descriptive findings, we develop an empirical model to quantify the cross-country differences in patenting which we label "technological trajectories". We use balanced panel data 1902-2016.[16] Our main estimating equation is:

$$\begin{aligned} \text{Patents}_{jkt} = \beta_k \cdot \textit{trend} + \alpha_1 \text{PTOFriendliness}_{jt} + \alpha_2 \text{HomeBias}_{jkt} \\ + \alpha_3 X_{kt} + \theta_{jk} + \varepsilon_{jkt} \end{aligned} \tag{1}$$

where Patents_{jkt} denotes the number of patents filed in patent office j assigned to country k in year t. The key set of coefficients are the β_k on the time trend, *trend*,

[16]We start the panel data from 1902 because patents from the French Patent Office are systematically recorded with assignee country information from 1902 onwards.

which represent assignee-country specific trends across multiple patent offices: our "technological trajectories". These are a quantitative way of summarising the trends we verbally described in Figures III and IV in a single number for a country.

We choose the UK as the base group, so trajectories are all relative to the UK. Note that the β_k are specific to the sample used. Trajectories are expected to be different in different historical periods. Similarly, they will likely differ depending on the set of countries considered, as they are all relative measures. We will explore both of these aspects below.

We include several controls (and show sensitivity to their exclusion) in equation (1). First, we include assignee-country by patent office fixed effect (θ_{jk}) to control for permanent differences in the level of innovativeness (since we want to measure trends. Second, *PTOFriendliness* controls for the overall patent trends in a particular patent office. We define this as (the log of) the sum of all patents in that office in a particular year. This is to take into account that an office make become more (or less) friendly to IP protection due to changes in laws, practices, fees, culture, etc. These will be reflected in overall patenting from all countries.

Third, we include a term for $HomeBias_{jkt}$, indicating the sum of domestic patents a country's own office. Home bias is a well-recognised phenomenon, which we do not want to conflate with true underlying trajectories. For example, the US became the world's major issuer of patents in the 20th Century, so this will push up the perceived trajectory of America. We also allow the home bias indicator to be interacted with a time trend.

Fourth, X_{kt} represents additional potential controls at the assignee-country level. These include population so that the trajectories are effectively in terms of patents per capita (we would expect faster growing nations to do more patenting) and dummies for the two World Wars (WWI and $WWII$). In some specifications we also include the manufacturing share of GDP to allow for structural change; GDP per capita and a human capital index. We also interact these controls with country dummies. Note that there is a risk of over-controlling by adding in these variables. For example, a country with a stronger technological trajectory could enjoy faster GDP growth as a result of innovation.

Finally, ε_{jkt} is the error term, which we allow to exhibit serial correlation using the Newey–West methodology.[17] We also extensive performed robustness checks such as estimating by pseudo-Poisson Maximum Likelihood instead of OLS, including

[17]Our baseline allows up to five years autocorrelation as standard errors stabilised after this point. But nothing depends on the exact length of time we allow for auto-covariances.

additional controls and allowing for different functional forms (results available on request).

The methodology to recover technological trajectories generalises the intuition used in Section 3. We recover the (conditional on controls) relative patenting performance of country $k, k = 1, ..., K$ over multiple patent offices, $j, j = 1, ..., J$, over a number of years, $t, t = 1, ..., T$. In our main application, we are using four offices $K = 4$, up to 40 countries ($J = 40$) and up to 115 years ($t = 1902, ..., 2016$). But the approach can be used flexibly, for example by expanding the number of patent offices considered.[18]

4.2 Results

TABLE I. Long-Run Technological Trajectories (1902 - 2016)

Dep Var: *Number of Assigned Patents*	(1)	(2)	(3)	(4)	(5)	(6)	(7)
US Tech Trajectory	621.0***	493.5***	445.2***	328.1***	548.4***	510.9***	558.4***
	(114.0)	(73.19)	(56.85)	(23.55)	(93.70)	(83.46)	(92.98)
FR Tech Trajectory	98.14***	85.24***	73.03***	59.91***	92.11***	97.54***	94.64***
	(18.00)	(17.24)	(12.78)	(9.322)	(21.73)	(20.18)	(22.68)
DE Tech Trajectory	114.9***	95.08***	101.4***	105.7***	92.47***	94.19***	87.21***
	(10.20)	(9.900)	(10.18)	(11.06)	(12.73)	(11.21)	(11.90)
JP Tech Trajectory	433.5***	425.2***	370.4***	242.7***	482.3***	464.0***	496.3***
	(74.37)	(70.63)	(57.67)	(16.98)	(89.72)	(83.46)	(89.35)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Log(population)	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Home-bias Trends	-	Yes	Yes	Yes	Yes	Yes	Yes
Human Capital per Capita	-	-	Yes	-	-	-	-
Dropping USPTO	-	-	-	Yes	-	-	-
Dropping FRPTO	-	-	-	-	Yes	-	-
Dropping DEPTO	-	-	-	-	-	Yes	-
Dropping UKPTO	-	-	-	-	-	-	Yes
N	2280	2280	2160	1710	1710	1710	1710

Notes: OLS coefficients are results of estimating equation (1) with Newey-West standard errors (in parentheses) allowing serial correlation up to fifth order. Technological trajectories (β_k) are all relative to the UK, the omitted base group (US = United States, FR = France, DE = Germany and JP = Japan). All columns include the following *Controls*: assignee country-by-office fixed effects, WW1/WW2-by-assignee country dummies and *PTOFriendliness* measured by the Log(Total number of patents in the office). *Homebias* is the sum of all domestic patents (and its interaction with a time trend). *HumanCapital* is the log of the human capital index from long-run educational dataset by (Barro and Lee, 2013). *, ** and *** represent significance at the 10%, 5% and 1% level respectively. Columns (4) - (7) drop data from one of the four patent offices of the US (USTPO), France (FRPTO), Germany (DEPTO), and the UK (UKPTO) respectively

Long-run Innovation Gaps. Table I shows the results of estimating a stripped down version of equation (1) examining the technological trajectories of the US, France,

[18]In general, it is better to use balanced panels, as unbalanced panels implicitly give more weight in the regression to those series with more observations.

Germany, and Japan with respect to the base group, the UK. The coefficients are significant for all countries, indicating that their technological trends were all stronger than the UK on average over the whole sample period. In column (1) we observe that the US has the largest coefficient, equivalent to 621 more annual patents than the UK. Japan is second with 434 more patents, followed by Germany, then France.[19] Column (2) of Table I includes our home bias control, which reduces the differences in technological trajectories to some extent. In particular, the US coefficient falls from 621 to 493. column (3) includes human capital as a further control. Although the variable is positive and significant, it makes little difference to the technological trajectories.[20] As countries might be more dominant in specific patent offices, we experiment with dropping each patent office separately in columns (4) through (7). Across all these columns, the ranking of technological trajectories across countries remains robust.

TABLE II. Technological Trajectories by Different Time Periods

Dep. Var. *Number of Assignees*	(1) 1902-2017	(2) 1902-1940	(3) 1940-1970	(4) 1970-1985	(5) 1985-2000	(6) 2000-2016
US Tech Trajectory	493.5***	-81.72	345.5***	161.3	1643.9**	240.3
	(73.19)	(44.53)	(83.90)	(230.2)	(540.1)	(155.8)
FR Tech Trajectory	85.24***	16.31	-38.66	160.1	187.5	117.5
	(17.24)	(10.55)	(53.17)	(114.6)	(133.8)	(171.2)
DE Tech Trajectory	95.08***	31.87**	187.8***	90.95	562.4***	-314.0
	(9.900)	(9.744)	(46.56)	(57.70)	(107.6)	(307.0)
JP Tech Trajectory	425.2***	-81.14*	-17.31	602.6**	378.1*	130.7
	(70.63)	(41.02)	(56.25)	(226.5)	(149.2)	(345.5)
Full Controls	Yes	Yes	Yes	Yes	Yes	Yes
N of Obs	2280	740	620	300	300	340

Notes: This table divides the analysis of Table I into separate time periods. OLS coefficients are results of estimating equation (1) with Newey-West standard errors (in parentheses) allowing serial correlation up to fifth order. Technological trajectories (β_k) are all relative to the UK, the omitted base group (US = United States, FR = France, DE = Germany and JP = Japan). All columns include *Full Controls* of assignee country-by-office fixed effects, WW1/WW2-by-assignee country dummies, *PTOFriendliness* measured by the Log(Total number of patents in the office), *Homebias* and the Log(Population). *, ** and *** represent significance at the 10%, 5% and 1% level respectively.

Innovation Gaps by Period. Technological trajectories may change across different historical periods. Consequently, Table II estimates equation (1) for alternative time windows. We consider five periods: (i) pre-WW2, (ii) 1940-1970, (iii) 1970-1985, (iv) 1985-2000, and (v) 2000-2016. Column (1) simply replicates column (2) from Table I

[19] Differences across countries are significant. For example, the Japan-US difference in column (1) has an F-Statistic of 8.24 (p-value = 0.004), and this finding is robust across specifications.

[20] Including log GDP per capita as an additional control variable also made little difference to the results, although the variable was positive and significant. For example in column (2), the coefficient (standard error) on GDP per capita was 2582(923). The estimated technological trajectories were 506, 75, 81 and 402 for the US, France, Germany and Japan respectively. This compares to 493, 85, 95, 425 in the shown column (2) specification without GDP per capita.

as a benchmark. Column (2) shows that in the first half of the 20th century, Germany stands had the strongest trajectory. This likely reflects its rapid industrialization and emphasis on science-based manufacturing. There was no US advantage in column (2) and it is only in the aftermath of WW2, that America really took off technologically as shown in columns (3) - (6). Germany continued to also grow strongly over this period, but ran out of steam in the 21st century (see column (6)). Japan's technological take-off began only after 1970 (see column (4)). The strongest period was 1970-1985, corresponding with its high-growth era, export-oriented industrial policy, and large investments in human and physical capital. There was no significant difference between France and Britain post WW2, although the France did a little better as indicated by the positive coefficients in all periods except 1940-70 (see column (3)).

TABLE III. Technological Trajectories: China in the Post-1990 Period

Dep. Var. *Number of Assignees*	(1)	(2)	(3)
US Tech Trajectory	308.2***	529.3***	483.8***
	(47.27)	(159.1)	(166.9)
FR Tech Trajectory	116.4**	133.3*	101.8
	(58.14)	(69.48)	(75.64)
DE Tech Trajectory	238.3***	26.85	33.31
	(48.90)	(141.3)	(139.7)
JP Tech Trajectory	426.6***	215.9	217.2
	(122.4)	(170.4)	(169.4)
CN Tech Trajectory	201.8***	279.6***	183.1
	(62.85)	(84.57)	(115.0)
Controls	Yes	Yes	Yes
Log(population)	-	Yes	Yes
Manufacturing share	-	-	Yes
Observations	648	648	648

Notes: OLS coefficients are results of estimating equation (1) with Newey-West standard errors (in parentheses) allowing serial correlation up to fifth order. Technological trajectories (β_k) are all relative to the UK, the omitted base group (US = United States, FR = France, DE = Germany, JP = Japan and CN = China). All columns include *controls* of assignee country-by-office fixed effects, *PTOFriendliness* measured by the Log(Total number of patents in the office), *Homebias* is the sum of all domestic patents (and its interaction with a time trend) and *Human Capital*. *Manufacturing Share* is the proportion of GDP int he manufacturing sector lagged ten years. *, ** and *** represent significance at the 10%, 5% and 1% level respectively.

The Rise of Chinese Innovation. Based on the descriptive analysis in Figure IV, we saw that China had reduced the innovation gap with its counterparts after 2000. Table III probes these patterns, by focusing on the post-1990 period and including China. Columns (1) and (2) show a significant and positive Chinese coefficient when estimating equation (1). Focusing on controlling for population growth in the second column, we see that China has a higher technological trajectory for all countries except for the

US, producing 279 more patents on average than the UK, for example. Column (3) includes the lagged fraction of GDP in the manufacturing sector as a control.[21] The coefficient on China falls by over a third and is no longer statistically significant, whereas the other coefficients fall by much less. This suggests that part of the reason for China's technological rise is linked to its growing strength in manufacturing becoming the new "workshop of the world".

5 Patterns of Technological Trajectories across many countries

We now turn to the relationship between our technology trajectory measures and macro-economic variables. To do this we need a wider range of countries where we have such data which is only available for more recent decades. We focus on 1960-2016 and a sample of 40 countries.[22] We implement equation (1) and provide the countries used in the analysis and the corresponding average values of the technological trajectories in Table IV and Figure V. These show that our analysis in Section 3 remains robust when other countries are included. The US, Japan and Germany maintain a substantially lead over other countries. Broadly we can distinguish three groups: the "top ten" from Japan to Sweden who have trajectories significantly faster than the UK. The "bottom dozen" from Norway to Bulgaria, who have trajectories significantly slower than the UK. And a middle group of 18 countries who have trajectories that are not significantly different to the UK.

Next, we take these 40 technology trajectories and explore their correlation with the growth of other productivity indicators. In Figure VI, we show the correlation between technological trajectories and the annual growth rate of TFP, labour productivity (GDP per hour) and capital intensity (capital stock per hour worked). We find a strong, statistically significant correlation with TFP growth, although it is far from perfect. Japan, the US and Germany have stronger trajectories than TFP growth, whereas the opposite is true for Hungary, Bulgaria and Portugal. This is consistent with the idea that much TFP growth is about the diffusion of new technologies rather than innovation at the frontier. The correlation of trajectories with labour productivity and capital intensity growth are also positive, but weaker and statistically insignificant. For example, the OLS slope is 0.434 for TFP, 0.114 for labour productivity and 0.192

[21] We use the value ten years ago in order to mitigate reverse causality. Note that the inclusion of this variable in Table I made much less difference to the results.

[22] See Appendix for more on the rationale for the exact choice of countries.

TABLE IV. Estimated Technological Trajectories across many Countries (1960-2016)

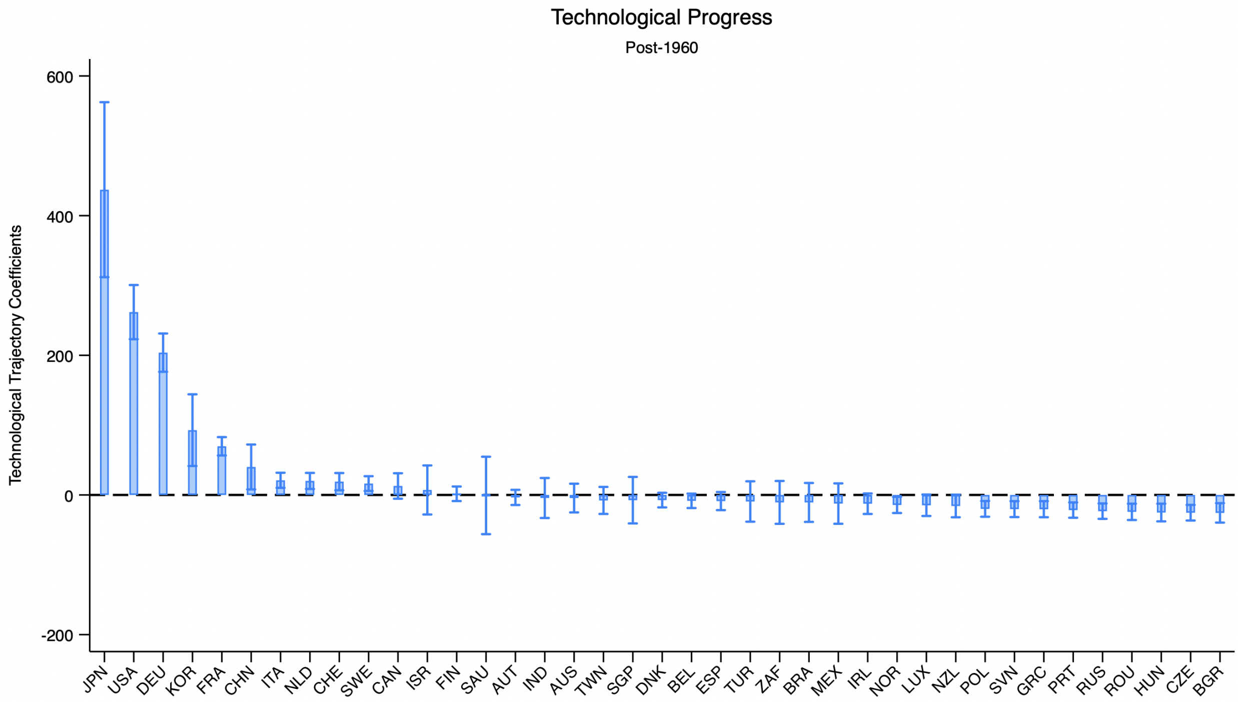
Country Name	Country Abb.	Technological Trajectory (τ)	Standard Error
Japan	JPN	437.12	(63.91)
United States	USA	261.82	(19.80)
Germany	DEU	203.80	(13.98)
South Korea	KOR	92.76	(26.18)
France	FRA	69.69	(6.70)
China	CHN	40.07	(16.39)
Italy	ITA	20.98	(5.52)
Netherlands	NLD	20.06	(5.88)
Switzerland	CHE	19.05	(6.29)
Sweden	SWE	16.29	(5.37)
Canada	CAN	12.85	(9.31)
Israel	ISR	7.14	(17.91)
Finland	FIN	1.67	(5.31)
Saudi Arabia	SAU	-0.72	(28.27)
Austria	AUT	-3.53	(5.53)
India	IND	-4.35	(14.60)
Australia	AUS	-4.45	(10.47)
Taiwan	TWN	-7.84	(9.87)
Singapore	SGP	-7.47	(16.98)
Denmark	DNK	-7.34	(5.33)
Belgium	BEL	-8.42	(5.26)
Spain	ESP	-8.78	(6.58)
Turkiye	TUR	-9.34	(14.74)
South Africa	ZAF	-10.64	(15.65)
Brazil	BRA	-10.69	(14.21)
Mexico	MEX	-12.36	(14.74)
Ireland	IRL	-12.54	(7.49)
Norway	NOR	-14.34	(5.88)
Luxembourg	LUX	-14.75	(7.82)
New Zealand	NZL	-15.80	(8.25)
Poland	POL	-19.95	(5.74)
Slovenia	SVN	-20.27	(5.81)
Greece	GRC	-20.37	(5.88)
Portugal	PRT	-21.69	(5.58)
Russia	RUS	-23.22	(5.62)
Romania	ROU	-24.17	(5.95)
Hungary	HUN	-25.15	(6.44)
Czechia	CZE	-25.44	(5.70)
Bulgaria	BGR	-25.69	(7.09)
N		9120	

Notes: Coefficients and standard errors for the technological trajectories for each country compared to the United Kingdom based on equation (1). Standard errors are Newey-West of order 5.

for capital intensity. These results are consistent with the idea that TFP trends partially reflect technical change, as measured by patenting. The weaker relationship for the other two metrics also makes sense as these are less closely related to technological change.

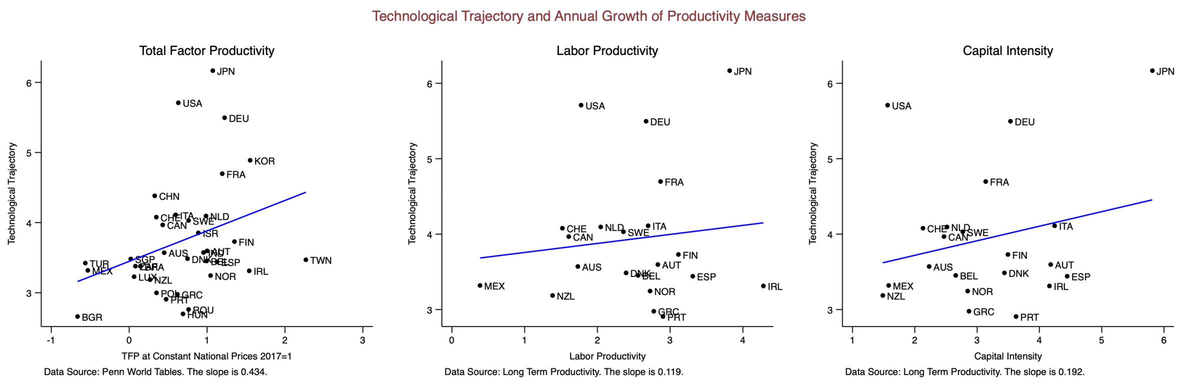
What could be the underlying "innovation drivers" of our technological trajectories? We have no natural experiments to estimate causal impacts, but we look at associations with six commonly discussed variables: research inputs (as measured by R&D expenditure per capita or the fraction of workers who are researchers), education (as measured by the proportion of the population with tertiary education or the human

FIGURE V. Estimated Technological Trajectories across many Countries (1960-2016)



Notes: Coefficients and standard errors for the technological trajectories for each country compared to the UK based on equation (1). Standard errors are Newey-West of order 5. Full details in Table IV.

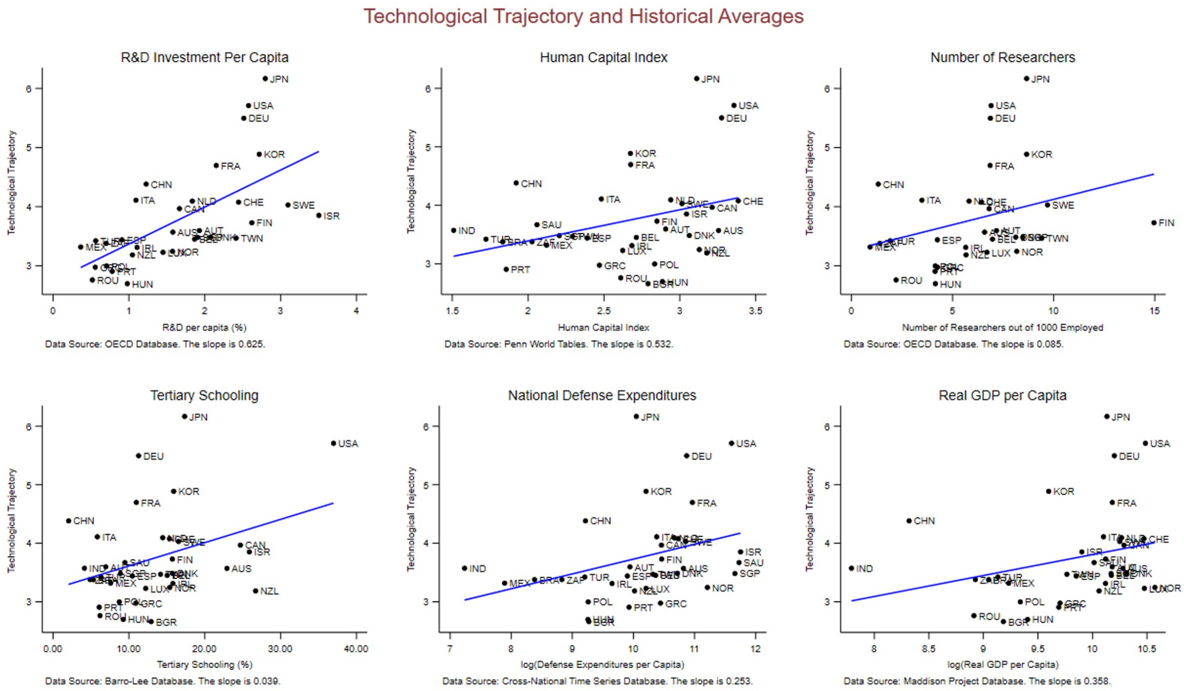
FIGURE VI. Technological Trajectories and Productivity Growth



Notes: Panels shows the correlation between technological trajectories shown in Table IV and the 1960-2016 growth rates of total factor productivity, labour productivity and capital intensity. The correlation coefficient is statistically significant at the 5% level for TFP growth, and insignificant for labour productivity growth and capital intensity growth.

capital index), defence expenditures per capita and GDP per capita (to capture convergence or divergence). In Figure VII we correlate technological trajectories with the

FIGURE VII. Technological Trajectories and Innovation Drivers (averages)



Notes: We show the correlation between technological trajectories shown in Table Table IV and the historical averages of R&D investment per capita (1981-2016), the human capital index (1960-2016), number of researchers per 1000 employees (1981-2016), tertiary schooling rate (1960-2010), national defence expenditures per capita (1970-2016), and real GDP per capita (1960-2016). Correlation coefficients are all statistically significant at least at the 10% level or greater.

1960-2016 averages of these variables. We uncover strong and significantly positive correlations with all of these innovation drivers.

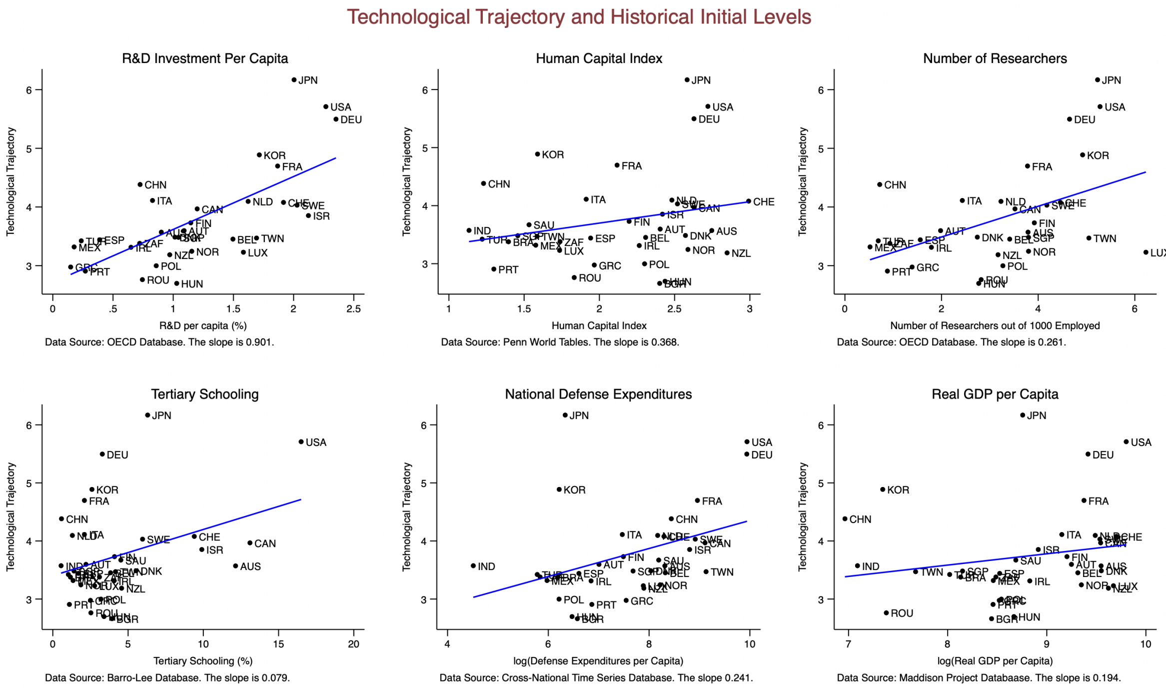
We also looked at other potential drivers. For example, we investigated whether there was any robust relationship with inequality, but we found that the correlations were insignificant.[23]

Of course, a concern with these associations is that there may be reverse causality - for example, firms in countries on a faster technological trend may decide to investment more in R&D. To partially address this issue, we next focus on initial conditions, using values of the innovation drivers at the start of the sample, so that they are pre-determined. Figure VIII contains the results of this experiment. All of the indicators remain positive, although only four of the six correlations remain significant at the 10% level or greater (R&D investment, researcher share, defence expenditure per

[23]For example, the coefficient (standard error) on the wealth share of the top 1% in column (2) of I was 8.916 (147.3).

capita and the fraction in tertiary schooling).[24]

FIGURE VIII. Technological Trajectories and (initial values of) Innovation Drivers



Notes: This panel shows the correlation between technological trajectories estimated in Table IV and historical initial levels of R&D investment per capita, human capital index, number of researchers per 1000 employed (1981), tertiary schooling rate, national defence expenditures per capita, and real GDP per capita. For each country, we use the earliest available observation from 1960 onwards. All statistically significant at least at the 10% confidence level except for human capital index and real GDP per capita figures.

In summary, we have validated that technological trajectories are related to TFP growth, but contain more information. Countries with initial levels of education and/or R&D do seem to maintain a technological edge over many decades.

6 Conclusions

In this paper, we have proposed a methodology for measuring the underlying innovation capability trends of a country, which we label technological trajectories. We have assembled data on countries from the early 19$^{\text{th}}$ century through the 2010s focusing on four different patents offices in the US, UK, France and Germany. By leverag-

[24]We also examined the association of technological trajectories with changes of the innovation drivers, but since the latter are rather persistent over time these correlations were insignificant.

ing foreign patent office data, we argue that we can construct globally comparable measures of innovation trends.

We describe the rise of the US, Germany, Japan and China at different historical conjunctures and the relative decline of the UK and, to a lesser extent, France. We implement our econometric methodology confirming the descriptive analysis and then focus on 40 countries over the 1960-2016 period. We show that the technological trajectories are related to (although not reducible to) TFP trends. We find that the core drivers of the trajectories are education, R&D and defense investment.

We are making the data used here public use and believe our Technological Trajectories could be useful for other researchers. The methodology is quite general and can be generalised in many ways to more patent offices, countries and time periods. Further research on the drivers of the trajectories is an obvious next step.

References

Acemoglu, Daron, Philippe Aghion, and Fabrizio Zilibotti, "Growth, development, and appropriate versus inappropriate institutions," *EBRD-Japan Research Programme Papers, Banque européenne pour la reconstruction et le développement, Londres*, 2006.

Aghion, Philippe, Antonin Bergeaud, Matthieu Lequien, Marc J Melitz, and Thomas Zuber, "Opposing firm-level responses to the China shock: Output competition versus input supply," *American Economic Journal: Economic Policy*, 2024, *16* (2), 249–269.

Akcigit, Ufuk and Tom Nicholas, "History, microdata, and endogenous growth," *Annual Review of Economics*, 2019, *11* (1), 615–633.

_ , John Grigsby, and Tom Nicholas, "Immigration and the rise of American ingenuity," *American Economic Review*, 2017, *107* (5), 327–331.

Allen, Robert C, *The British industrial revolution in global perspective*, Cambridge University Press, 2009.

Barro, Robert J and Jong Wha Lee, "A new data set of educational attainment in the world, 1950–2010," *Journal of development economics*, 2013, *104*, 184–198.

Baruffaldi, Stefano, Brigitte van Beuzekom, Hélène Dernis, Dietmar Harhoff, Nandan Rao, David Rosenfeld, and Mariagrazia Squicciarini, "Identifying and measuring developments in artificial intelligence: Making the impossible possible," 2020.

Bergeaud, Antonin and Cyril Verluise, "The rise of China's technological power: the perspective from frontier technologies," Discussion Paper DP1876, Centre for Economic Performance, London School of Economics and Poiltical Science 2022.

_ and _ , "A new dataset to study a century of innovation in Europe and in the US," *Research Policy*, 2024, *53* (1), 104903.

— **and** — , "A new dataset to study a century of innovation in Europe and in the US," *Research Policy*, 2024, *53* (1), 104903.

— **, Gilbert Cette, and Remy Lecat**, "GDP per capita in advanced countries over the 20th century," 2015.

— **,** — **, and Rémy Lecat**, "Productivity trends in advanced countries between 1890 and 2012," *Review of Income and Wealth*, 2016, *62* (3), 420–444.

Berkes, Enrico, "Comprehensive universe of US patents (CUSP): data and facts," 2018. Unpublished, Ohio State University.

— **, Matthew Lee Chen, and Matteo Tranchero**, "300 years of British patents," *Research Policy*, 2026, *55* (1), 105347.

Broadberry, Stephen N, "Technological leadership and productivity leadership in manufacturing since the Industrial Revolution: Implications for the convergence debate," *The Economic Journal*, 1994, *104* (423), 291–302.

— **and Douglas A Irwin**, "Labor productivity in the United States and the United Kingdom during the nineteenth century," *Explorations in economic history*, 2006, *43* (2), 257–279.

— **, Kyoji Fukao, and Nick Zammit**, "How did japan catch-up on the west? a sectoral analysis of anglo-japanese productivity differences, 1885-2000," 2015.

Coluccia, Davide M and Gaia Dossi, "Return innovation: The knowledge spillovers of the British migration to the United States, 1870-1940," Technical Report, Centre for Economic Performance, LSE 2025.

David, Paul A and Gavin Wright, "Early twentieth century productivity growth dynamics: An inquiry into the economic history of" our ignorance"," 1999.

Dechezleprêtre, Antoine, Yann Ménière, and Myriam Mohnen, "International patent families: From application strategies to statistical indicators," *Research Policy*, 2017, *46* (1), 269–283.

Dosi, Giovanni, "Technological paradigms and technological trajectories: a suggested interpretation of the determinants and directions of technical change," *Research Policy*, 1982, *3* (11), 147–162.

Dulken, Stephen Van et al., "British patents of invention, 1617-1977: a guide for researchers," *(No Title)*, 1999.

Hall, Bronwyn H., Adam B. Jaffe, and Manuel Trajtenberg, "The NBER patent citation data file: Lessons, insights and methodological tools," *Journal of Economic Perspectives*, 2010, *24* (2), 403–432.

Khan, B Zorina, "Premium inventions: patents and prizes as incentive mechanisms in Britain and the United States, 1750-1930," in "Understanding long-run economic growth: geography, institutions, and the knowledge economy," University of Chicago Press, 2008, pp. 205–234.

Kogan, Leonid, Dimitris Papanikolaou, Amit Seru, and Noah Stoffman, "Technological innovation, resource allocation, and growth," *The quarterly journal of economics*, 2017, *132* (2), 665–712.

Kortum, Samuel and Josh Lerner, "What is behind the recent surge in patenting?," *Research policy*, 1999, *28* (1), 1–22.

Madsen, Jakob B, "The Aging Society: Is Growth Reverting to Pre-Industrial Levels in the 21st Century?," 2024.

Mokyr, Joel, *The Enlightened economy an economic history of Britain 1700-1850*, Yale University Press, 2010.

Naudé, Wim and Paula Nagler, "The rise and fall of German innovation," Technical Report, IZA Discussion Papers 2021.

Nicholas, Tom, "Cheaper patents," *Research Policy*, 2011, *40* (2), 325–339.

OECD, *OECD Patent Statistics Manual*, OECD publishing, 2009.

Petralia, Sergio, Pierre-Alexandre Balland, and David L Rigby, "Unveiling the geography of historical patents in the United States from 1836 to 1975," *Scientific data*, 2016, *3* (1), 1–14.

Qiu, Shumin, Claudia Steinwender, and Pierre Azoulay, "Paper tiger? Chinese science and home bias in citations," *Journal of International Economics*, 2025, p. 104123.

Rassenfosse, Gaètan De, Helene Dernis, Dominique Guellec, Lucio Picci, and Bruno Van Pottelsberghe De La Potterie, "The worldwide count of priority patents: A new indicator of inventive activity," *Research Policy*, 2013, *42* (3), 720–737.

Santacreu, Ana Maria and Heting Zhu, "What does Chinaâ€™ S rise in patents mean? A look at quality vs. Quantity," *A Look at Quality vs. Quantity*, 2018, pp. 1–2.

Sarada, Sarada, Michael J Andrews, and Nicolas L Ziebarth, "Changes in the demographics of American inventors, 1870–1940," *Explorations in Economic History*, 2019, *74*, 101275.

Soete, Luc and Sally Wyatt, "The use of foreign patenting as an internationally comparable science and technology output indicator," *Scientometrics*, 1983, *5*, 31–54.

Sokoloff, Kenneth L, "Invention, innovation, and manufacturing productivity growth in the antebellum Northeast," in "American Economic Growth and Standards of Living before the Civil War," University of Chicago Press, 1992, pp. 345–384.

Wright, Gavin, "The origins of American industrial success, 1879-1940," *The American Economic Review*, 1990, pp. 651–668.

Online Appendix - Not Intended for Publication

A Data Appendix

A.1 PatentCity

Assignees, Inventors, and Citizenship. The location of the patentee is crucial for pinpointing the origin of innovative activities. However, the type of information on the patentee's location varies across patent offices and countries. This difference primarily stems from varying approaches by patent offices regarding the recording of information on assignees and inventors.

During the 19^{th} century, in many countries, the distinction between an assignee and an inventor was vague, except for the United States. The United States Patent and Trademark Office (USPTO) has published all patents with assignee and inventor locations separately since 1836, whereas Great Britain, Germany, and France at the time did not have specific identifications for inventors and assignees. For example, only firm names could appear without a person's name in a patent file. In such cases, these firms are recorded as the assignee in PatentCity. However, if both a company name and a person's name are present, they are recorded as the assignee and the inventor, respectively. If only a person's name appears in the patent file, they are recorded as the inventor, who is also technically the assignee of the patent. In most cases, the inventor and the assignee were the same entity. Therefore, our analysis collected the assignee information based on the information provided in patent files.

Since assignees hold ownership rights over patents, we prioritize applicant country information. In cases where applicant country data is unavailable, we use inventor country information. Our primary source is the assignee country information listed in the patent file. In some cases, however, neither an assignee country nor an inventor country is available. These are relatively rare and typically arise when the OCR system is unable to extract country information from older patent documents. For such instances, we use additional information on the applicant's citizenship, which is available for patents filed at the US and UK patent offices. While citizenship is not needed for USPTO patents, where inventor and assignee information is reliably recorded, it proves useful for older UK filings where metadata are sparse.

A.2 PATSTAT

Designation States. Our analysis begins with granted patents from the European Patent Office (EPO) and World Intellectual Property Organization (WIPO) serving as event authorities. A designation country is where applicants seek patent protection in specific jurisdictions. Between 1978 and 2010, applicants paid country-specific fees for the desired designation states. Therefore, the set of designation states was determined by the choice of assignees and could vary across applications due to differences in pricing. Since 2010, all European Patent Office (EPO) patent applications automatically designate all qualifying states by default. Although applicants can request the removal of specific states, this rarely occurs because there is no additional cost associated with designating all states. Consequently, after 2010, designation states are assigned by default and offer little to no variation. Due to the decrease in local patent filings, we combine PatentCity with EPO patents extracted from PATSTAT since 1978, with the information on designation states. Regarding designation states, our focus is on the first set of countries designated before any renewals.

For each designated country, we compute the share of patents attributed to foreign applicants, again applying fractional counts in the case of multiple countries. This harmonized procedure ensures consistency across offices and enables meaningful international comparison of innovative activity in the post-1978 era.

A.3 Choice of Countries

The choice of countries is determined as follows: First, we ranked countries based on the total number of assignees from 1960 to 2016 in all four patent offices as described in the data section. Then we select a cutoff of 2,500 patents to include as many as countries possible with potentially available long-run historical data. From this initial set, we exclude Barbados, the Virgin Islands, the Cayman Islands, and Liechtenstein, which are primarily associated with tax-haven activity rather than domestic innovative effort. We further exclude Ukraine, since it was not an independent country prior to 1991. After applying these exclusions, our final sample consists of 40 countries.

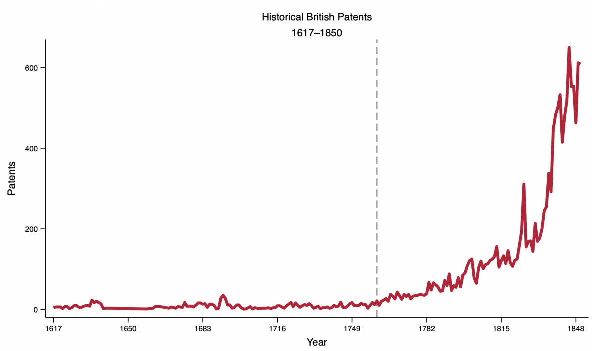
A.4 British Patents from 1617 onwards

Beginning in the early modern period, Britain laid the groundwork for formal innovation protection through the issuance of letters patent—exclusive rights granted by the Crown as early as 1617. Though initially rooted in medieval privileges, these gradually took on economic aims: to incentivize the disclosure of new techniques. With the Industrial Revolution, patenting increased markedly, reflecting both rising inventive activity and the growing institutionalization of intellectual property (see Figure A1).

Yet the British patent system was also the subject of sustained criticism. It was expensive, opaque, and administratively fragmented. Unlike the streamlined U.S. system introduced in 1790, British applicants faced separate filings across England, Scotland, and Ireland, with total costs often exceeding £100—several years of income for a skilled artisan (Khan, 2008). This effectively restricted access to wealthy inventors, often based in urban areas or linked to industrial capital. Many key contributors to British technological progress, especially artisan-innovators, were excluded from formal protection due to financial or legal barriers (Mokyr, 2010).

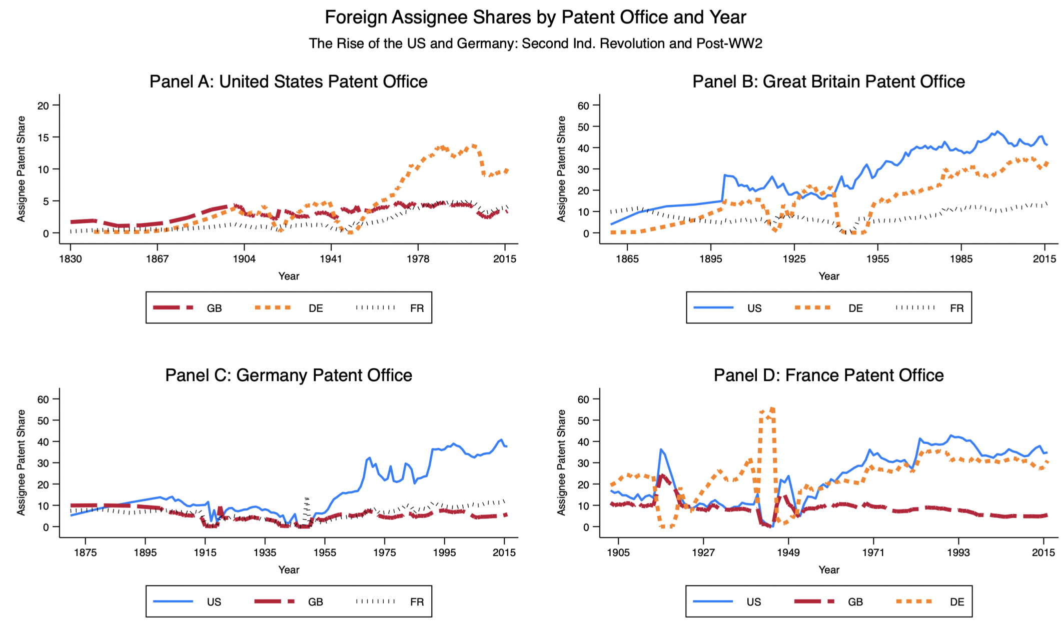
Meaningful reforms only came in the second half of the 19th century. The Patent Law Amendment Act of 1852 centralized the system under a single UK office. The 1883 Patents, Designs, and Trade Marks Act simplified procedures and sharply reduced fees by 84%, bringing British practice closer to international standards (Van Dulken et al., 1999). There was a sharp rise in filings after these reforms. As Nicholas (2011) shows, patenting propensity increased significantly, especially among corporate entities, even though the geographic distribution of inventive activity remained stable. The reform thus reduced institutional frictions without changing the underlying geography of innovation, broadening participation in the formal system rather than shifting its core.

FIGURE A1. British Industrial Revolution and Innovations



Notes: Number of historical patents in Great Britain until 1850. The reference line indicates the start of the First Industrial Revolution. Source: Early British Patents.

FIGURE A2. Country shares of non-domestic patents in Foreign Patent Offices - Annual Values



Notes:The share of assignees from named country as a share of all non-domestic applicants. For example, the UK has about a 4% share of all non-US assigned patents in the USPTO in 1990. Each panel is from a different patent office. These are the same as Figure III, except are in annual values.