THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE

Economic History Student Working Papers No: 002

Innovation Under Central Planning: patenting and productivity in the GDR

Titus Frieling

Submitted as partial fulfilment of the MSc in Economic History 2020-21

December 2021

Economic History Department, London School of Economics and Political Science,
Houghton Street, London, WC2A 2AE, London, UK. T: +44 (0) 20 7955 7084.

Innovation Under Central Planning: patenting and productivity in the GDR

Titus Frieling

Abstract
This thesis employs novel datasets on patenting activity and TFP in the GDR to study the relationship between innovation and productivity. Patenting activity is chosen as a variable of interest due to its inherent link to the innovative process and high international and intertemporal comparability. No statistically significant relationship between patenting and future productivity growth is found in an analysis across 16 sectors of the GDR's economy from 1950-1989. This result is unusual, and likely results out of the institutional framework of the GDR: firstly, it being a planned economy and the associated reduced productivity effects of innovations, and secondly, the GDR's unique patent system which likely increased the number of patent applications while reducing their economic usefulness. By including the full breadth of the GDR's patent stock, as well as robustly estimating the initial capital stock of the GDR, a more reliable account of both these variables can be made than was possible in previous studies. This thesis contributes to the literature through its use of new data and an adaptation of a proven empirical identification strategy to a new context. It also suggests avenues for further research on the relationship between patenting and innovation in the GDR and planned economies more widely.

Introduction

The German Democratic Republic, or GDR, was a socialist bridgehead in the developed world, and in many respects the jewel in the crown of soviet-aligned economies. Nonetheless, in comparison with their "compatriots" due West, citizens of the GDR lived less free and less prosperous lives. This was partially due to the weaknesses inherent to all planned economies, and partially due to the suboptimal endowments of the GDR's territory.

The GDR's state-led R&D programmes were driven by severe structural disproportions that afflicted the East German economy from the end of WWII to Reunification. The issue was not so much that East Germany was economically backwards, but that put simply, it was an "incomplete" economy.[1] Its endowments in capital were not distributed equally throughout the value chain: while it had an established consumer goods industry, it was lacking in primary and capital goods production.[2] This led to problems in supplying its industry, that were compounded by its weak transport sector, which had suffered severe war damage and dismantlement, which could not be repaired easily due to a lack of domestic steel capacity – in fact, East German railways would never again have as much track as before the war.[3] Without trade with the rest of Germany and the world, the East German economy could not function properly.[4] The autarky required of East Germany by the low-trade environment in the post-war communist bloc reduced the scope for "Smithian" gains from specialisation and required immense investments, which were already predicted to be a major drain on the East German economy in 1948.[5] For an example: the East German metalworking industry produced 65% of the entire worldwide product portfolio, whereas the FRG's only produced 17%.[6] At the same time, the communist system promised improved living standards for the masses and abundance for all. This generated a crushing "internal contradiction" (even though the GDR hoped to escape the Marxian contradictions of Capitalism): Communism promised higher living standards, but reaching these given the GDR's endowments required massive investments, which in turn, required restraint in living standards – contradicting the promise of socialist bounty. This fundamental and structural problem was not lost on the GDR's leadership and would ultimately prove the GDR's undoing, and the GDR's leadership settled on technological improvement as the only way to ultimately overcome the problem.

But this project failed: the GDR's flagship high-technology enterprise, Robotron, only introduced the 1MB microchip (to great fanfare) a full *six years* after it had

---

[1] Karlsch, *Allein Bezahlt?*
[2] Ritschl and Vonyó, 'The Roots of Economic Failure', 169–71.
[3] Ritschl and Vonyó, 176–77; Karlsch, *Allein Bezahlt?*, 91.
[4] Karlsch, *Allein Bezahlt?*, 92.
[5] Karlsch, 43.
[6] Dale, *Between State Capitalism and Globalisation*, 165.

been developed in the West. In other segments of the economy, the GDR similarly lay well behind the global cutting edge (its most-produced car, which had a years-long waitlist, was designed in the 1950s).

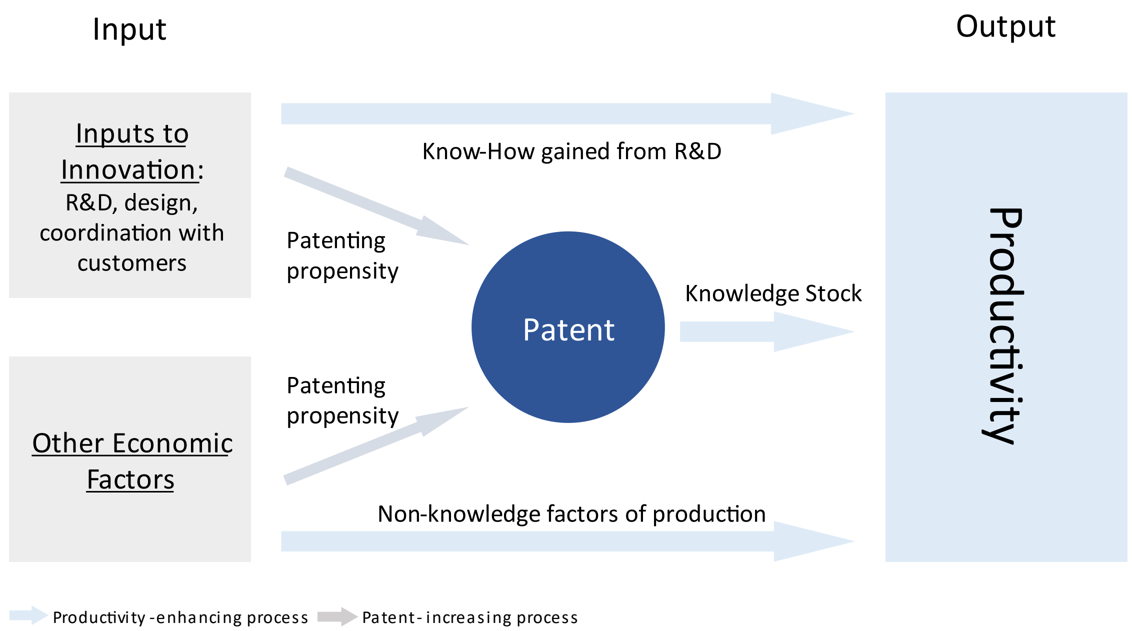
In this dissertation, I study the link between the GDR's research and development complex and its economy through the vector of patenting. I choose patenting because it is the most internationally comparable and constant institutionalised manifestation of innovation outcomes. My thesis will answer the research question "what was the link between patenting and productivity in the GDR" in four major parts. Firstly, I review the literature on the link of patenting and productivity internationally, introduce peculiarities of the GDR and studies on the local links between TFP and innovation. Secondly, I provide context on my research and generate hypotheses in a historiographical section. Thirdly, I introduce my empirical method, which is adapted from the literature, and the data series I have compiled. Finally, I provide and discuss my statistical results.

I do not find a statistically significant relationship between patenting and productivity, and propose that this is due to the institutional structure of the GDR's economy and patent system, which creates a "noisier" set of patent data that requires intense archival research to supplement. I propose some further avenues of research using data that exists in German archives but could not be used for the purposes of this study.

Literature Review

In this section I will first illustrate the relationship between innovation, patents and productivity, which is not straightforward. As Figure 1 illustrates, not only is productivity strongly affected through non-patent channels that relate to knowledge, but also by factors completely unrelated to knowledge. Patents provide an indicator of the former, the stock of knowledge that can be employed in production because, generally, they let the patentee monopolise the use of an invention as a "reward" for disseminating the contents of the invention in form of the patent.[7] But difficulties remain. For instance, the propensity to patent innovations differs substantially by sector as the ease of circumventing patents varies significantly depending on the field.[8] Moreover, patents do not perfectly measure improvements to production, as "A Patent is not an innovation, but [...] patent information constitutes some kind of a bridge between the results of a particular company's R&D activity and implementation activity".[9] Since the relationship is indirect, "Patent Metadata" like citations and licenses, the longevity of the patent, and the size of the patent family can also provide insights.[10] A number of approaches that have used such data have yielded interesting results and will be described in the following literature review.

Figure 1: The relationship between patents and productivity



Adapted from Nagaoka et al. (2010) to fit the GDR's institutional context.[11]

[7] Plant, 'The Economic Theory Concerning Patents for Inventions'.
[8] Horstmann, MacDonald, and Slivinski, 'Patents as Information Transfer Mechanisms', 828.
[9] Wisła, 'Patent Data in Economic Analysis', 75.
[10] Wisła, 76.
[11] Nagaoka, Motohashi, and Goto, 'Patent Statistics as an Innovation Indicator', 1105 fig. 10; adapted from Pakes and Griliches, 'Patents and R and D at the Firm Level'.

Part I: Innovation, patents, and productivity internationally

Stock of knowledge

One way to interpret patents is as elements of the stock of knowledge, as for instance Griffith et al. (2004) do.[12] They analyse the stock of knowledge, consisting of a depreciated stock of patents, and propose that the rate of return to this stock of knowledge depends on the distance from the TFP frontier. They find a significant and positive relationship between patents and TFP. Cubel and Esteve add international trade as a source of knowledge transfer and consider also the stock of knowledge of trading partners, similarly finding a significant positive relationship.[13] Naudé and Nagler use the number of successful patent applications as an indicator in the relationship between innovation and productivity in (West) Germany and argue that these provide a good indicator, allowing them to conclude that factors such as insufficient entrepreneurialism drove weaknesses in productivity growth in particular eras.[14]

Distinguishing patents by their economic value

As only a minority of patents are ever used, and only a minority of those provide substantial economic value, researchers can improve their findings by using metadata to distinguish between patents. The main measures are patent citations and patent longevity. The first measure, citations, is employed by Hall et al. (2005) to show that firms with patents that receive more citations have higher market valuations than those with fewer citations, all other things being equal.[15] The second measure, patent longevity, is used in many different papers and takes advantage of the fact that most countries charge periodic and escalating “renewal fees” to inventors to maintain the monopoly granted by a patent.[16] Schankerman and Pakes pioneered this approach for the post-1950 period in Europe, finding that renewal data shows a highly skewed distribution

---

[12] Griffith, Redding, and Reenen, ‘Mapping the Two Faces of R&D’.
[13] Cubel and Esteve, ‘The Effect of Foreign and Domestic Patents on Total Factor Productivity during the Second Half of the 20th Century’.
[14] Naudé and Nagler, ‘Technological Innovation, Entrepreneurship and Productivity in Germany, 1871-2015’.
[15] Hall, Jaffe, and Trajtenberg, ‘Market Value and Patent Citations’.
[16] Wisła, ‘Patent Data in Economic Analysis’.

of the economic value of patents and a relatively high "depreciation rate".[17] In the German context, Streb et al (2006) and Burhop (2010) use the longevity of patents to estimate their value, which lets them understand the role of high-value patents in knowledge transmission throughout the economy.[18]

From this brief review of the international literature, it is evident that there is a link between patents and productivity, but that it is contingent on several factors whose which should be considered in research.

Intermezzo: Unique Challenges in studying the GDR

Patent data is always to some extent tied to a national context, and this is doubly true in the GDR because of its socialist character and several historical factors unique to a country borne out of partition. In the following, I will briefly introduce how the innovation system itself, as well as the transmission of innovations into productivity was profoundly affected by the Socialist model, and how consequently the approach to studying the relationship between patenting and innovation must be adapted.

Innovation in planned economies

Productivity in planned economies is usually lower than in market economies, and one reason put forth for this is that planned economies are fundamentally worse at improving productivity through innovation. Chiang (1990) provides a rigorous argument for why planned economies are expected to fare worse than their free-market counterparts in implementing innovations. Managers in planned economies are rewarded or punished according to their ability to fulfil production quotas, which means that they are loath to take the risk associated with implementing a new technique, which might pay off over the longer term but cause short-term disruptions in production.[19] In the GDR, this phenomenon

[17] Schankerman and Pakes, 'Estimates of the Value of Patent Rights in European Countries During the Post-1950 Period'.
[18] Streb, Baten, and Yin, 'Technological and Geographical Knowledge Spillover in the German Empire 1877-1918'; Burhop, 'The Transfer of Patents in Imperial Germany'.
[19] Chiang, 'Management of Technology in Centrally Planned Economies'.

is well-documented and derided as the “ton ideology,” because as plans often specified output targets by weight, improvements to the quality and usefulness of actual products were not important – and could even hinder the fulfilment of plan goals if they entailed creating a lighter product![20] Moreover, while planned economies like the GDR could produce high-quality research in many areas, applied scientific work at some point relied on outputs of the industrial sector, which often could not provide the adequate instruments and raw materials. Lamenting the difficulty of progressing in research when there was not an ecosystem of high-quality suppliers, the Carl Zeiss researcher Paul Görlich complained that “In the West, competition and the general pace of development [force] even the smallest operation to produce world-class products (or go under), whereas in our country a tired pace lacking in energy is accompanied by slogans [exhorting East Germans to try to reach] the worldwide level [of technological development]."[21] Thus, progress was hindered by structural problems inherent to planned economies, both in the adoption of innovations and in the creation of innovative output itself. As such, the link between research and development and productivity improvements is weaker in the GDR than elsewhere.

Political interference in research

To examine this link, one must also consider that the research process could not proceed unimpeded. The GDR’s leadership pursued autarkic policies, which did much to misdirect research and investment. For instance, many attempts were made to substitute oil with coal in petrochemical processes, although this was not promising.[22] The microelectronics field, which was particularly dear to the Politburo (one might call it a white elephant) was also held back by political interference. Research of thin-film microelectronics was prioritised over transistors, despite the fact that this was not considered a promising field

[20] Augustine, *Red Prometheus*, 88.
[21] Augustine, 164.
[22] Stokes, ‘Von Trabbi Und Acetylen - Die Technikentwicklung’.

anywhere and Werner Hartmann, the leader in the field in the GDR, strenuously objected.[23]

In some fields, the GDR attempted to jump-start its technological progress by way of directly copying western products. Microelectronics was a major priority for the GDR's leadership and saw the first clandestine copying of foreign microchips in 1967.[24] Since this was illegal, it led to a culture of secrecy which harmed innovation flows between teams and especially between institutions. It also made it difficult to sell goods abroad – copyright violations were quite obvious to foreign buyers.[25]

Microelectronics suffered particularly badly from MfS activities, as Hartmann was disgraced due to (unfounded) suspicions of sabotage, robbing the microelectronics research establishment of one of its most brilliant and important leaders.[26] His colleague Paul Görlich, who was cited above complaining about the difficulty of creating excellent work in a planned economy, was also ousted due to suspicions of espionage. All this was despite the fact that the GDR microelectronics field was several years behind the world leaders and the GDR leadership put a great deal of faith in the potential for high technology to solve intrinsic problems of the GDR's economy (more on that later).

The Patent system

An additional issue that arises out of the GDR being a socialist country is the specific structure of the GDR patent system, which differs from non-socialist countries. The politicians, officials, and planners of the GDR were firm believers in the power of technology, which motivated them to quickly re-establish the patent system after the chaos of the post-war years.[27] Moreover, planners wanted to take advantage of the international knowledge flows created by the

---

[23] Augustine, 'Management of Technological Innovation'.
[24] Augustine.
[25] Augustine.
[26] Augustine, *Red Prometheus*, 165.
[27] Wiessner, 'Das Patentrecht der DDR', 241–43.

patent system, which is why the GDR joined international treaties on patent standardisation. However, they were quite opposed to the monopolistic associations of the concept of the patent.[28] As such, the 1950 patent law had initially only permitted the "Wirtschaftspatent", in which patentees could not prohibit anyone from using their invention – instead, potential licensees approached the patent office (Amt für Erfindungs- und Patentwesen, or AfEP) for the permission to use the patent. Whether or not this permission was granted was the discretion of AfEP and would result in the payment of a license fee to the patentee.[29] This contrasts heavily with the usual practice in capitalist societies, in which the holders of patents have the exclusive right to decide on their use.[30] The Wirtschaftspatent had obvious limitations. Firstly, it conflicted with Paris treaties on the harmonisation of international patents, which the GDR was party to.[31] Secondly, it was unattractive to foreign patentees, who would not accede to the mandatory licensing of the Wirtschaftspatent.[32] This would have cut the GDR off from a vital source of international knowledge transfer and harmed the potential for technology-enabled growth. As such, the patent office introduced the "Ausschließungspatent" which conferred a right to exclude – although this was almost exclusively issued to international patentees, and made up a minority of patents.[33] Since the majority of patents did not convey the exclusive right to use an innovation, patents differ fundamentally as an output of the R&D system and as a factor of productivity improvement. For instance, the proportion of patents that are actually used is around 50% for most countries,[34] but was only 20% in the GDR,[35] which makes it all the more important to use some method to assess the value of patents.

---

[28] Wiessner, 254.
[29] Wiessner, 253–54.
[30] Plant, 'The Economic Theory Concerning Patents for Inventions'.
[31] Wiessner, 'Das Patentrecht der DDR', 259.
[32] Wiessner, 259.
[33] Wiessner, 259.
[34] Motohashi, 'Licensing or Not Licensing?'; in Nagaoka, Motohashi, and Goto, 'Patent Statistics as an Innovation Indicator', 1110.
[35] Lindig, 'Ausgewählte Rahmenbedingungen Des Erfinderischen Schaffens in Der DDR'.

Moreover, understanding the patenting activities of firms in the GDR is very difficult. Firstly, there was substantial reorganisation of the economy (initial nationalisation, creation of VVB and later Kombinate, etc.) which creates continuity problems. More importantly, the usual distinction between "inventor" and "applicant" (i.e. patent owner) was simply not made in the 1960s, except for foreign patents.[36] This creates a period for which hardly any organisation-level patenting data can be constructed from the DEPATISnet dataset. Another issue is that data on the GDR's innovation activity is relatively scarce. Firstly, international patent databases like PATSTAT generally do not contain any reliable information on GDR patents before 1973. Secondly, the data that does exist is structurally different from that found in other systems. For instance, the number of patent citations is not useful, both due to unreliable databases and because GDR citation rates are significantly lower – this might be due to lower international trade or other systemic differences (or indeed simply due to their lower value). The most cited patent from the GDR has 893 citations, compared to 6304 for the FRG.[37] Secondly, Patent longevity data is generally not available: Patents lasted for 18 years and did not have to be renewed.[38] Finally, data on patent families is scarce, especially before 1973 – at which point there was a dire lack of hard currency in the GDR which was more needed elsewhere than for international patenting. Alternative data exists, but is in difficult-to-access archives. As such, studies on patenting and productivity in the GDR must overcome limitations in the availability of data.

Part II: Innovation, Patents, and Productivity in the GDR

Accordingly, many studies on productivity and innovation in the GDR have not used patent data, in many cases reviewing qualitative evidence and company instead. Augustine (2007, 2020) argues that in the microelectronics sector, innovation in *scientific* terms (the production of new scientific findings) was strong, but hurt by politically motivated firings of key staff. This also hurt the

[36] Kogut and Zander, 'Did Socialism Fail to Innovate?'
[37] PATSTAT online, accessed 26.08.2021
[38] Wiessner, 'Das Patentrecht der DDR'.

implementation of scientific knowledge into productivity-enhancing improvements, which was poor in any case. Moreover, the problems associated with illicit copying mentioned above worsened both *scientific* and *implementation* outcomes.[39] Other studies particularly focus on the integration of the GDR into the communist bloc as a source of frictions in the innovative process. Fengler finds that the Filmfabrik Wolfen suffered particularly because of decisions to integrate completely into the communist bloc, which made it difficult to reach the technological frontier.[40] Schiefer's extensive study of the petrochemical sector and notes key differences in the power of the Stasi between firms.[41] Stokes also notes the friction caused by the fact that existing linkages to researchers and suppliers were cut and replaced by exchanges of personnel and know-how with the Eastern Bloc.[42] There have also been several studies on productivity and innovation in the wider eastern bloc which I can only briefly mention here. Broadberry and Klein argue that Czech planners created acceptable productivity growth until the age of "flexible mass production."[43] Allen instead holds that Soviet productivity growth slows down around the 1970s as excessive focus is put on the military in R&D and investments.[44] Vonyó similarly considers initial underinvestment and subsequent misallocation of investments to be a major drag on productivity growth.[45] His criticism of official investment figures vindicates this thesis' approach, mirroring Glitz and Meyersson (2020) of relying on Heske's revised investment estimates.[46]

A case study approach

Kogut and Zander (2000) use a case study approach to study the Carl Zeiss company that was split after the war.[47] At this point, many scientists and

[39] Augustine, *Red Prometheus*; Augustine, 'Management of Technological Innovation'.
[40] Fengler, 'Innovation in a Centrally Planned Economy: The Case of the Filmfabrik Wolfen'.
[41] Schiefer, *Profiteur Der Krise*.
[42] Stokes, 'Von Trabbi Und Acetylen - Die Technikentwicklung'.
[43] Broadberry and Klein, 'When and Why Did Eastern European Economies Begin to Fail?'
[44] Allen, 'The Rise and Decline of the Soviet Economy'.
[45] Vonyó, 'War and Socialism'.
[46] Glitz and Meyersson, 'Industrial Espionage and Productivity'; Heske, 'Value Added, Employment and Capital Expenditures in the East German Industry, 1950-2000'.
[47] Kogut and Zander, 'Did Socialism Fail to Innovate?'

technicians left for the new location in Oberkochen in Swabia, while the intellectual property and other capital remained in Jena. They analyse the correlation between technical field of patents filed by the two Zeiss firms and find a very high degree of continuity, despite the split. They note that VEB (and later Kombinat) Carl Zeiss Jena was highly innovative in many fields and saw great successes in photomask manufacturing (needed for semiconductor production) which Carl Zeiss Oberkochen was not a serious player in. Their title "Did socialism fail to innovate" suggests a potential for making generalised conclusions from the results on Zeiss, but this is complicated by the fact that Zeiss was a passion project for Walter Ulbricht and played a major role in the armaments research industry, even coming to the attention of Leonid Brezhnev himself.[48] Zeiss, while a fascinating case study, simply lacks generalisability to the wider GDR economy.

Comparing the GDR with the FRG

Glitz and Meyersson (hereafter: GM2020) conducted a landmark study of GDR productivity and how it relates to industrial espionage, also accounting for patenting. My own approach is significantly indebted to their work, which is why I describe the data, method, and results in the GM2020 paper in great detail here. Considering the structural impediments to the implementation of new technologies in planned economies, they propose that patenting is unlikely to be a good predictor of productivity improvements. Instead, they analyse industrial espionage activities by the MfS as a likely source of more economically useful knowledge inflows. This has been an area of interest for research at least since an MfS defector turned over troves of Data to German authorities in 1979.[49] The opinions on the actual effects of espionage differ, however: while some researchers discount the effectiveness of the espionage programme, Glitz and

[48] Augustine, *Red Prometheus*, 183; Augustine, 'Management of Technological Innovation', 11.
[49] SPIEGEL, 'DDR-Spionage'.

Meyersson find it to have reduced the TFP gap between East and West Germany.[50]

GM2020 use panel data on patenting, TFP, and MfS industrial espionage on 16 different sectors in the GDR and FRG. They create the TFP time series by using a dataset compiled by Gerhard Heske, a former member of the GDR's State Planning commission, who was engaged in a multi-year project of revising the official (i.e., formerly classified) figures on employment, investment, output, and price inflation.[51] This dataset is among the most reliable available for the GDR, and Heske is a true expert in the field. Using this dataset, they construct a number of TFP series with different underlying assumptions on the initial capital stock.

For their patent data in the GDR, they use a dataset of GDR patents obtained from AfEP records which lists all patents applied for by each Kombinat, which can then be assigned to sectors through the activity of the specific Kombinat. The dataset runs from 1971 to 1989. For the FRG, they obtain data from DEPATISnet which is assigned to a particular sector using a concordance table between the patent class (IPC) and the International Standard Industry Classification (ISIC).[52] This dataset runs from 1970-1989. The main focus of the analysis is not patenting but industrial espionage, for which they construct a variable based on a database on Stasi activities.

Their regression model is a dynamic panel regression of the gap in TFP between east and West on several independent variables with a three-year lag, analysing multiple overlapping three-year windows with year and sector fixed effects. They have three major results. First, without including the lagged TFP gap in the independent variables, the coefficient on the lagged patent gap is positive and

[50] For comparison: Macrakis, 'Das Ringen um den technischen Höchststand: Spionage und Technologietransfer in der DDR'.
[51] Heske, 'Value Added, Employment and Capital Expenditures in the East German Industry, 1950-2000'.
[52] Verspagen, van Moergastel, and Slabbers, 'MERIT Concordance Table: IPC - ISIC (Rev. 2)'.

statistically significant. Secondly, when including the lagged TFP gap, the coefficient on the lagged patent gap is not significant, but the lagged TFP gap is highly significant. Finally, when including lagged industrial espionage, the coefficient on espionage is positive and significant, as is the coefficient on the TFP gap, but patents are non-significant.[53] They conclude that the GDR's economy benefitted very strongly from MfS espionage and suggest that the Stasi was uniquely effective in its task, potentially due to the cultural closeness of the two Germanies and the ability to cheaply motivate informants with socialist ideology.[54]

Remaining Questions

There is clear evidence that internationally, there is a link between patents, innovation, and productivity. But the only study that addresses this link directly employs a comparative approach and is mostly focused on studying the impacts of industrial espionage, with an only incidental use of patent statistics. While their findings are interesting, concerns remain about the comparability of their data, due to the different attribution of patents to sector. As such, I believe that when using a different dataset, a significant improvement can be obtained in the understanding of the link between patenting and productivity in the GDR.

The historical circumstances of the GDR mean that patent data needs to be treated uniquely. Firstly, I wish to argue that the GDR's patent law likely makes patents a better measure of the pure, unweighted output of R&D activity than in other countries. This is because the drawbacks of patenting (revealing sensitive information, patenting/renewal fees) are absent in a planned economy without competitive pressure, the benefits of patenting, though reduced in comparison to market economies, were still present: user fees were paid to patentees and prolific inventors could receive medals and honours such as "Verdienter Erfinder."[55] However, this means that patents are more likely to be economically

---

[53] Glitz and Meyersson, 'Industrial Espionage and Productivity'.
[54] Glitz and Meyersson.
[55] Wiessner, 'Das Patentrecht der DDR'.

useless, since important "filtering" such as initial fees and renewal fees are absent in the GDR context, as demonstrated by the lower utilisation rate of patents in the GDR of 20% rather than 50%. As such, while they likely to be a "purer" measure of R&D output, they are also likely to be noisier as they will contain more results of low applicability. At the same time, the complications in planned economies noted above mean that patent applications are likely a relatively worse measure of innovation that improves productivity. Absent competition and a profit motive, there was very little reason to attempt an innovative strategy if this conflicted at all with planned output goals. This means that the overall link between patenting activity and productivity growth is likely to be smaller in the GDR than elsewhere. As such, I want to evaluate whether the number of patent applications in a given sector of the economy in the GDR is associated with a change in total factor productivity of that sector.

Historiography

To provide a better understanding of the subject matter, as well as elaborate on the specific challenges inherent to working in the GDR, I will now provide some general historical background on the GDR's economy and research system. This will allow me to formulate hypothesis to direct my further research in subsequent sections.

1945-1949

In the Research and Innovation sphere, the post-war years saw a scramble for talent between the Eastern and Western blocs. While both sides were happy to ignore complicity or even active involvement in Nazi crimes, the Soviets were particularly lenient.[56] Many scientists were recruited to work in remote research institutions in desolate areas like Siberia. In some cases, this recruitment was forced and wholly unwelcome, but in other cases Soviets recruited scientists with generous pay and other perks – researchers were permitted to take family,

---

[56] Augustine, *Red Prometheus*.

furniture, even lovers to the remote research institutes they were expected to work at for the future.[57] During this time, many became exposed to socialism and found it far more benign than the dreadful caricature presented by Nazi propaganda, some even coming to prefer it to Western-style liberal democracy for Germany.[58] The GDR leadership found it easy to rehabilitate even previously ardent Nazis as the scramble for talent and the need to construct the scientific establishment that would lead to the development of socialism presented a more important imperative that the righting of historical wrongs.[59]

<u>1950s</u>

The 1950s saw the gradual return of scientists and researchers from their “leaves of absence” in the USSR. But not all was well for the R&D establishment, as the better political freedoms and higher living standards in West Germany continued attracting talent. The GDR needed to urgently improve the living standards of the technical intelligentsia (and other segments of society) to reduce emigration, but instead it enacted real wage cuts in 1953 that triggered a popular uprising that had to be crushed by the Red Army. [60]

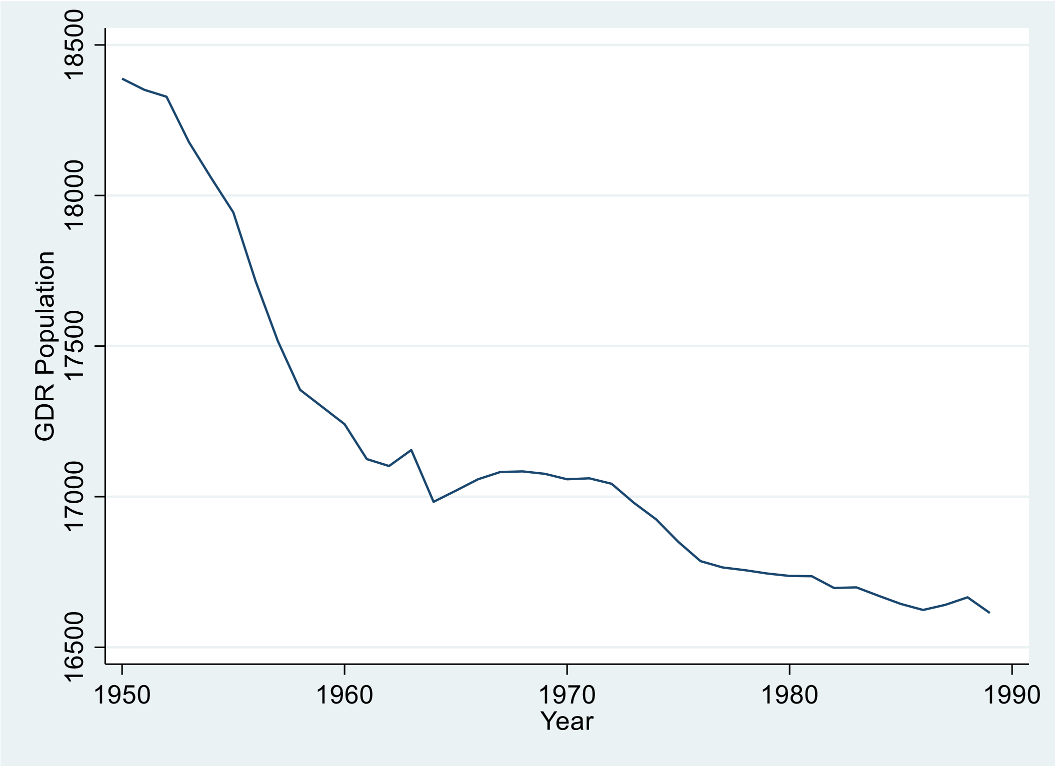
This policy was necessitated by the dual burden of Soviet Reparations and severe production bottlenecks. Thus, the first five-year plan was forced to invest in the primary sector and low-value added products like basic chemicals instead of building up high-value added sectors such as synthetic fibres or consumer goods. [61] However, the 1953 uprising led to a lasting fear of imposing wage restraint to finance investments on part of the SED (recalling the dilemma introduced above), and so while Investment in the primary sector remained high in the 1950s, other sectors saw less investment than their West German counterparts and productivity growth was sluggish.[62] Moreover, emigration remained a major

---

[57] Augustine, 7–12.
[58] Augustine, 15–18.
[59] Augustine, 31.
[60] Ritschl, ‘An Exercise in Futility’, 514.
[61] Karlsch, *Allein Bezahlt?*, 114; Ritschl, ‘An Exercise in Futility’, 513.
[62] Ritschl, ‘An Exercise in Futility’, 514–17.

problem as seen in Figure 1. Amazingly, while the western world was generally experiencing a "baby boom", the GDR's population continuously declined! Over a million mostly young and educated people fled to the more prosperous and freer west before 1961, reducing the human capital stock of the GDR.[63]

Figure 2: Population in the GDR, 1950-1989



Source: Franzmann 2007, ZA8267[64]

Under this early paradigm of lasting economic woes, the GDR leadership quickly settled on technological progress as the only hope for lasting prosperity in the GDR.[65] This belief in a *deus ex machina* to help save the regime was maintained throughout the GDR's history, in an ironic continuation of the Third Reich's obsession with building a high-tech *Wunderwaffe* to win an unwinnable war.[66] To this end, science was politicised like other parts of society in order to produce

[63] Karlsch, *Allein Bezahlt?*, 44.
[64] Franzmann, 'Bevölkerung in Der Ehemaligen DDR 1946-1989'.
[65] Stokes, 'Von Trabbi Und Acetylen - Die Technikentwicklung', 114.
[66] Augustine, 'The Failure of the East German Electronics Industry', 98.

innovations according to the needs of the plan.[67] In the late 1950s, an increase in COMECON trade led to an improvement of growth, partially due to a degree of lenience on the private sector.[68]

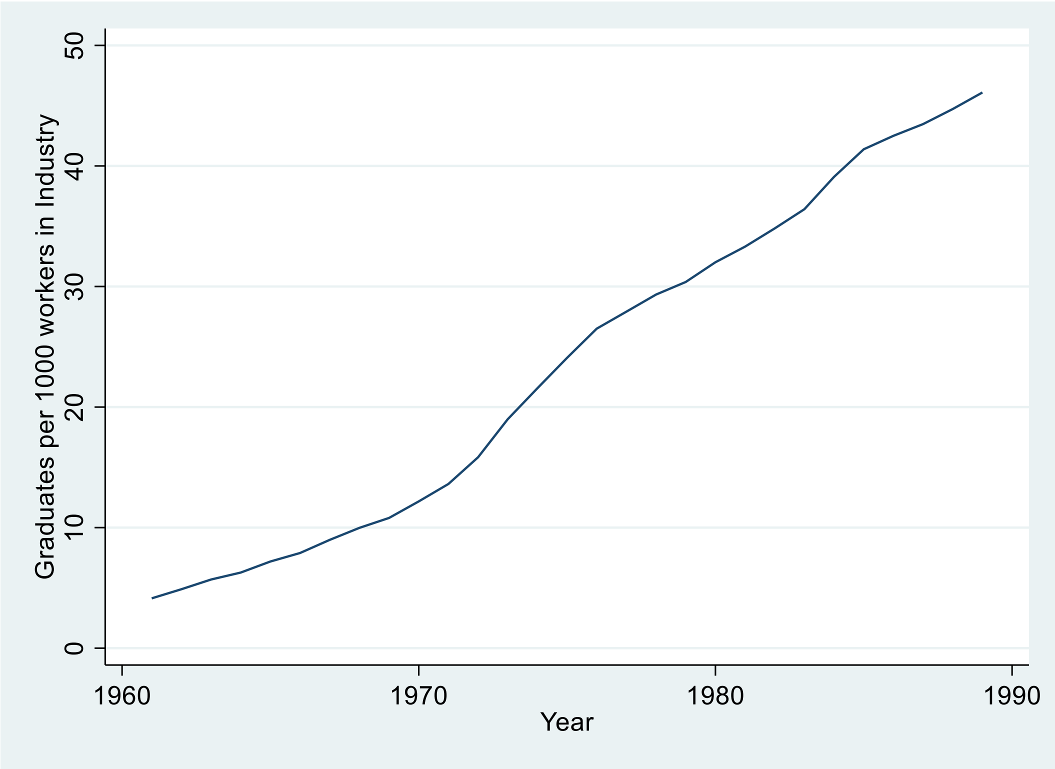
<u>1960s</u>

In 1961, the SED famously responded to the ongoing emigration problem by building the Berlin wall, which was effective in slowing the population decline (Figure 2).[69] However, the wall itself laid bare the failures of socialism in the GDR and thus suggested a need for reform. [70] At the same time, any meaningful deviation from past economic policy threatened the ideological position of the SED.[71] Nonetheless, the Ulbricht government, more able to focus on longer-term objectives with the short-term emigration issue resolved, went ahead with economic reforms under the "New economic system." In this, SOEs were to be permitted to retrain profits and central planning was to be replaced with more indirect "economic levers".[72] Faced with continuing economic difficulties, science and technology, and in particular "High Technology" in sectors like electronics again seemed like the only way to overcome the structural obstacles the GDR's economy faced. In 1963, technology was defined as a factor of production like capital or labour in the SED's formal ideology – analogous to the treatment of patents as a "knowledge stock" in the literature review.[73]

---

[67] Förtsch, 'Wissenschafts- und Technologiepolitik in der DDR', 20.
[68] Ritschl, 'An Exercise in Futility', 517.
[69] Ritschl, 'An Exercise in Futility'.
[70] Laitko, 'Das Reformpaket der sechziger Jahre', 56.
[71] Laitko, 42.
[72] Ritschl and Vonyó, 'The Roots of Economic Failure', 517.
[73] Förtsch, 'Wissenschafts- und Technologiepolitik in der DDR', 26.

Figure 3: Graduates per 1000 workers in industry



Source: Franzmann 2006, ZA 8266[74]

The 1960s saw a great deal of reform in the areas of Science and Technology as well. The education sector was successfully expanded, as can be seen by the near tripling of graduates per 1000 workers in industry from 4 to almost 12 over the 1960s (Figure 3). Moreover, investments into high-tech research were prioritised.[75] There was a plan to concentrate research staff in industry (which could now pay for R&D through profits) rather than science institutes, and the university research system was reorganised along bureaucratic lines, breaking the authority that senior faculty previously had.[76] The Science Secretariat was promoted into a full Ministry, which prioritised research on its own terms: promoting research into the substitution of lignite for oil, microelectronics, and

[74] Franzmann, 'Berufsausbildung Und Studium in Der Ehemaligen Deutschen Demokratischen Republik (DDR) von 1960 Bis 1989. Ein Überblick Anhand Der Amtlichen DDR-Statistik.'
[75] Dale, *Between State Capitalism and Globalisation*, 171; Ritschl, 'An Exercise in Futility', 518.
[76] Augustine, *Red Prometheus*, 100.

energy efficiency.[77] In this period we can already see negative effects of political meddling in research, such as in microelectronics where researchers were required to explore avenues outside of transistor technology, which reduced their productivity.[78] This was also when the practice of state-sponsored industrial espionage and copying of research emerged.[79]

Ultimately the reforms of the Ulbricht government could never be implemented. Investments ran into diminishing returns, accurately determining ROI absent a stock market was difficult, and profit-oriented management with its spectre of layoffs and restructuring provoked worker opposition.[80] At the same time, R&D staff was still mostly concentrated in institutes rather than industrial research complexes.[81]

<u>1970s</u>

The 1970s began with what was for all intents and purposes a coup d'état, as Erich Honecker took over the reins from Walter Ulbricht in a return to Marxist orthodoxy. The GDR avoided the 1973 oil crisis due to the COMECON's pricing policy of asking the lagged five-year average price for commodities. In fact, the GDR exported refined products produced from cheap COMECON oil to acquire foreign reserves.[82] Nonetheless, the balance sheet deteriorated, as the past decades of technological improvements had quite often been bought with foreign reserves, leading to a deteriorating balance sheet.[83] The GDR accumulated over 12 billion USD in foreign debt, which led to acute issues with financing imports - Honecker's "Union of Economic and Social policy" had financed what was

[77] Förtsch, 'Wissenschafts- und Technologiepolitik in der DDR', 26.
[78] Augustine, *Red Prometheus*, 7.
[79] Augustine, 9.
[80] Dale, *Between State Capitalism and Globalisation*, 175; Ritschl, 'An Exercise in Futility', 517–19.
[81] Laitko, 'Das Reformpaket der sechziger Jahre', 45.
[82] Stokes, 'East Germany and the Oil Crises of the 1970s', 139.
[83] Ritschl, 'An Exercise in Futility', 523.

essentially consumption spending through a welfare system through foreign borrowing.[84]

Academically, the Honecker Regime pursued centralisation of research and development into centralised institutes regardless of the suitability of local conditions.[85] Moreover, the effects of secrecy intensified, as Honecker placed more responsibility into the hands of the Stasi. This culminated in the ousting of Werner Hartmann, who had been a driving force in the GDR's microelectronics research field, in 1974.[86] Interestingly, this dismissal occurred *after* the SED recognised the critical importance of semiconductors and promoted massive investments into the field in the hopes of establishing a sort of monopoly over microelectronics in the Eastern bloc.

1980s

By the late 1970s, the previously generous terms of COMECON turned less advantageous, as the supply of oil was cut and prices were now well above well market levels. This led to crucial shortages across sectors, particularly in the petrochemical industry.[87] Moreover, the high debt from the 70s spiralled out of control and in 1983 the GDR found itself unable to import critical basic goods, and was only saved by a West German credit of 1 Bn DM.[88] The oil problems and foreign exchange shortages led to a further round of autarky programs, attempting to substitute oil with lignite.[89] These investments were very unproductive, and displaced other spending, such as elsewhere in the chemical sector.[90] The balance of payment consistently worsened, and by the late 80s only flagship projects like the high-tech sector and certain chemistry projects received significant investment or even refurbishment, as growing parts of the GDR's capital stock were simply left to depreciate away.

[84] Ritschl, 520.
[85] Buthmann, *Versagtes Vertrauen*, 256.
[86] Augustine, *Red Prometheus*, 184–86.
[87] Stokes, 'East Germany and the Oil Crises of the 1970s', 140.
[88] Ritschl, 'An Exercise in Futility', 522–23.
[89] Ritschl, 523.
[90] Schiefer, *Profiteur Der Krise*, 363.

At the same time, the research establishment suffered from excessive centralisation, which made recruitment of skilled individuals difficult.[91] Furthermore, research in many important sectors, such as microelectronics and optics, suffered greatly from the burdens of secrecy imposed by the copying of foreign technologies and the turn towards military production. By the late 1980s, it was not just the economy that had ossified and was in crisis, but the weight of over thirty years of political meddling in the scientific enterprise had reduced the ability for researchers to pursue creative avenues of research and the interest of firms to explore ways to improve production.

Data and Methodology

Considering this historical background, I want to investigate the link between patents and productivity in the GDR. Is the relationship as strong as in other countries? Why or why not? The specifics of the patent system and the historical background lead me to the hypothesis that the relationship between patenting activity and productivity growth is weaker than in other countries, but still positive and present. The relationship is likely to be weakened by the institutional context: firstly, being a planned economy, there is less likelihood of productive "knowledge spillovers" within the economy, as managers in firms are more concerned with maintaining current output than laying the groundwork for future productivity growth. Secondly, while the dominance of the "Wirtschaftspatent" reduces the payoff to inventors (especially at the very high end), there are still material rewards for patenting. At the same time, the costs of patenting, both directly in terms of fees and indirectly in terms of "giving away" knowledge to the competition, are absent – so the incentive to patent is still relatively strong. In the following sections, I introduce my strategy for testing this hypothesis using regression analysis and comparing the results to junctures in the historical record.

[91] Förtsch, 'Wissenschafts- und Technologiepolitik in der DDR', 31.

Patent Data

Due to my scepticism about the comparability of data employed by GM2020 for the GDR and FRG, I instead constructed a patent dataset for the GDR along the same lines as they did for the FRG. The data on patents in the GDR is scraped from DEPATISnet by selecting the application country as belonging to the GDR. The data spans the years from 1950 to 1990, covering almost the entire lifetime of the GDR – 1949 was omitted because the establishment of AfEP and the publication of the GDR's patent law only took place in 1950. Unlike data used in earlier research, the dataset is highly granular, down to the level of the individual patent, and it contains patents from all relevant economic actors: SOEs, private inventors, and foreign patentees. This granularity provides the researcher with a wealth of information, but also necessitates careful data preparation to avoid introducing errors. The first challenge is identifying the origin of the patentee – while all patents are from the GDR, and foreign patenting was rarer in the GDR than elsewhere, there are still many international patents, both from the Eastern and Western blocs.[92] While the data is in a structured format, and prepared using OCR on scanned patent forms, the data is not always consistent, and care must be taken to identify the characteristics of a foreign-owned patent. Country codes are present in many cases but are not consistent with regards to differentiating the GDR from the FRG. To identify foreign patents conclusively without creating many false positives, the data is therefore run through a filter that identifies certain country codes and other identifiers. Differentiating between foreign and domestic patents is helpful to understand the effect to which the international transfer of knowledge that they represent affected productivity in the GDR. The application date is taken to be the variable of interest as this is the point at which the R&D process has resulted in an invention – it is from this point that positive effects on productivity should be expected. It is chosen over the date of registration, as this depends crucially on administrative factors of the patent office that have little to do with the actual innovation process. To take advantage of the granularity of

[92] At over 40.000 they make up nearly 20% of the entire stock!

the economic data, which covers 16 distinct sectors, patents are assigned to the appropriate economic sector using the MERIT concordance table between IPC and ISIC and assigning the ISIC values to the appropriate industrial sectors.[93] The same method is employed in GM2020 for the assignment of patents to sectors in the FRG and is thus demonstrated as relatively robust. My patent dataset is thus more comprehensive and detailed, as well as more long-running than other data employed in the literature, while employing official records from post-unification Germany.

TFP Data

TFP is measured in the standard Cobb-Douglas form as the share of output not explained by the capital stock of labour, as specified in Equation 1 in which Y_{jt} is output for sector j and time t, A_{jt} is Total Factor Productivity, K_{jt} is the capital stock and L_{jt} is the labour force.

$$Y_{jt} = A_{jt} K_{jt}^{0.33} L_{jt}^{0.67} \quad (1)$$

The Heske dataset is the most up-to-date and comprehensive account of the output, workforce, and investment across sectors in the GDR, but it does not contain TFP data. As such, it is necessary to construct a series on the capital stock to calculate TFP, which requires making assumptions to impute an initial capital stock. In GM2020, only the period from 1971 onwards is covered, due to the coverage of the patent and espionage series. Two techniques are used to calculate TFP: For the main specification, a method derived from Caselli (2005), which calculates an initial capital stock using a steady state approach is used.

$$K_{jt} = I_{jt} + (1 - \delta) K_{jt-1} \quad (2)$$

The Capital stock K at time t in sector is given by Equation 2, and is simply the previous capital stock less depreciation and plus investment. To find an initial capital stock, Caselli proposes using a steady state approach in which the initial capital stock is calculated as described in Equation 3.

$$K_{j0} = \frac{I_{j0}}{g_j + \delta} \quad (3)$$

[93] Verspagen, van Moergastel, and Slabbers, 'MERIT Concordance Table: IPC - ISIC (Rev. 2)'.

In Equation 3 Investment is I, the geometric growth rate is g_j, and the depreciation rate is δ.[94] Glitz and Meyersson calculate the geometric growth rate from 1950-1970, which is before the period of study. Like Caselli, they select a depreciation rate of rate of 6%.[95] From this, a TFP series is constructed for each of the 16 sectors used by Heske.

They check the robustness of this approach by also employing a method proposed by the authors of the Penn World Table for use in transition economies. Inklaar and Timmer (2013) argue that in the case of economies undergoing a major transition, it can be more accurate to use an initial capital-output ratio of 2.6.[96] Both methods give relatively similar results in the GM2020 model, which is not surprising given that 20 years of depreciation and investment have been able to correct any initial mistakes by the time their analysis starts.

In the case of extending the analysis all the way to the beginning of the series, the choice of an initial capital stock is of course far more salient. As such, I have calculated another capital (and TFP) series based on the study of the GDR's early economy by Ritschl and Vonyó (2014) (hereafter: RV2014). They conduct a comprehensive review of war damage, dismantling, and investment to calculate a capital stock for the post-war years in East Germany, allowing them to report gross and net capital stocks, output, and employment in industry for the GDR in 1950.[97] Making their data usable was a multi-step process due to the different price levels and coverage of a slightly different share of the economy in their paper. Firstly, I had to calculate deflators for the 1944 and 1939 price levels using data from Appendix 1 to calculate the appropriate value for the net capital stock in 1936 in 1939 prices, as displayed in Table 1.

---

[94] Caselli, 'Chapter 9 Accounting for Cross-Country Income Differences'; in Glitz and Meyersson, 'Industrial Espionage and Productivity', 1075–76.
[95] Glitz and Meyersson, 'Industrial Espionage and Productivity', 1076.
[96] Inklaar and Timmer, 'Capital, Labor and TFP in PWT8.0'; in Glitz and Meyersson, 'Industrial Espionage and Productivity'.
[97] Ritschl and Vonyó, 'The Roots of Economic Failure'.

Table 1: 1936 figures in 1939 prices

Year	Price Level	Gross Capital stock	Net Capital Stock
1936	1939	16000	9195,83
1936	1944	17260	9920

Source: Ritschl and Vonyó 2014, own calculations.[98]

Subsequently, I calculated the appropriate 1950 output, capital, and labour figures using Tables A1, 2, and 3. To be able to use these figures with the Heske dataset, I made the fundamental assumption that the TFP and capital/worker ratio would be the same for marginal workers reported in the Heske data but not in the RV2014 data – as the number of workers was approximately 30% higher in the Heske dataset. As such, I scaled up output, capital, and workers linearly. The results are shown below, in Table 2. From this, I was able to compute an approximate "deflator" from the 1939 price levels to the price levels employed by Heske, and thereby estimate the initial capital stock.

Table 2: 1950 figures in 1939 prices

Year	Output	Gross Capital	Net Capital	Workers
1936	7600	16000	9195,829	1937
1950	6163,6	13504	7816,454	2355,392
1950 - scaled	8020,505	17572,34	10171,31	3065

Source: Ritschl and Vonyó 2014, own calculations.[99]

[98] Ritschl and Vonyó.
[99] Ritschl and Vonyó.

Table 3: Initial capital stocks calculated according to different baselines

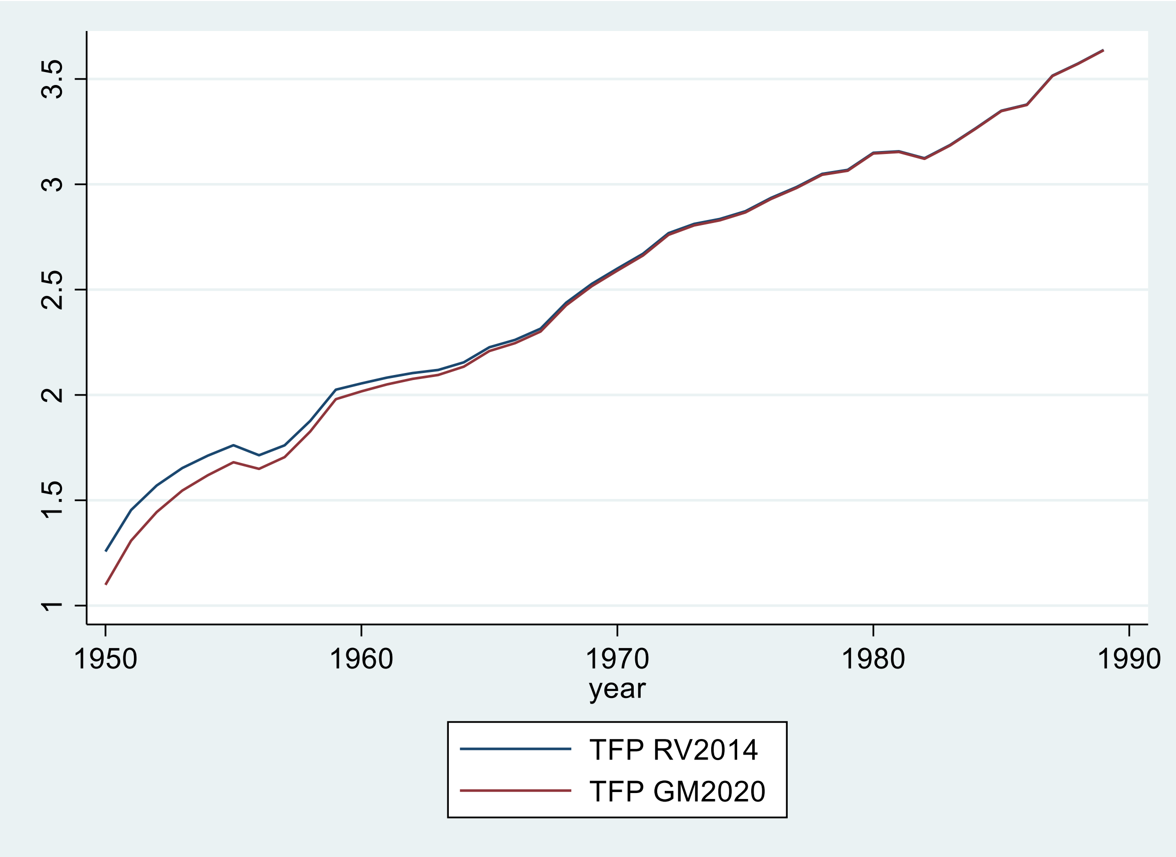
Source	Output	Capital	Capital-Output Ratio
Heske - Steady State	4846,783	9242	1,91
Heske - PWT	4846,783	12601,64	2,6
Ritschl and Vonyó	4846,783	6146,515	1,27

Source: Heske 2013, Glitz and Meyersson 2020, Ritschl and Vonyó 2014, own calculations.[100]

The initial capital stocks are visible in Table 3, and it is surprising how low the capital-output ratio implied in RV2014 is compared to the initial capital-output ratios calculated in GM2020 using the different approaches they used. Nevertheless, the calculation of the initial capital stock is not enough, as it still leaves the question on how to allocate it to different sectors, as the RV2014 data applies to the GDR as a whole. Again adapting the GM2020 method, I use two approaches. The first was to allocate the total capital based on the share of the total capital that each sector had in the Steady State model by Caselli. This approach combines the logical appeal of the Caselli method with the empirical basis of the RV2014 data. The other approach is to take a flat capital-labour ratio from the capital stock calculated from Ritschl and Vonyó and apply it to all sectors equally.

[100] Heske, 'Value Added, Employment and Capital Expenditures in the East German Industry, 1950-2000'; Glitz and Meyersson, 'Industrial Espionage and Productivity'; Ritschl and Vonyó, 'The Roots of Economic Failure'.

Figure 4: Whole-Economy TFP figures



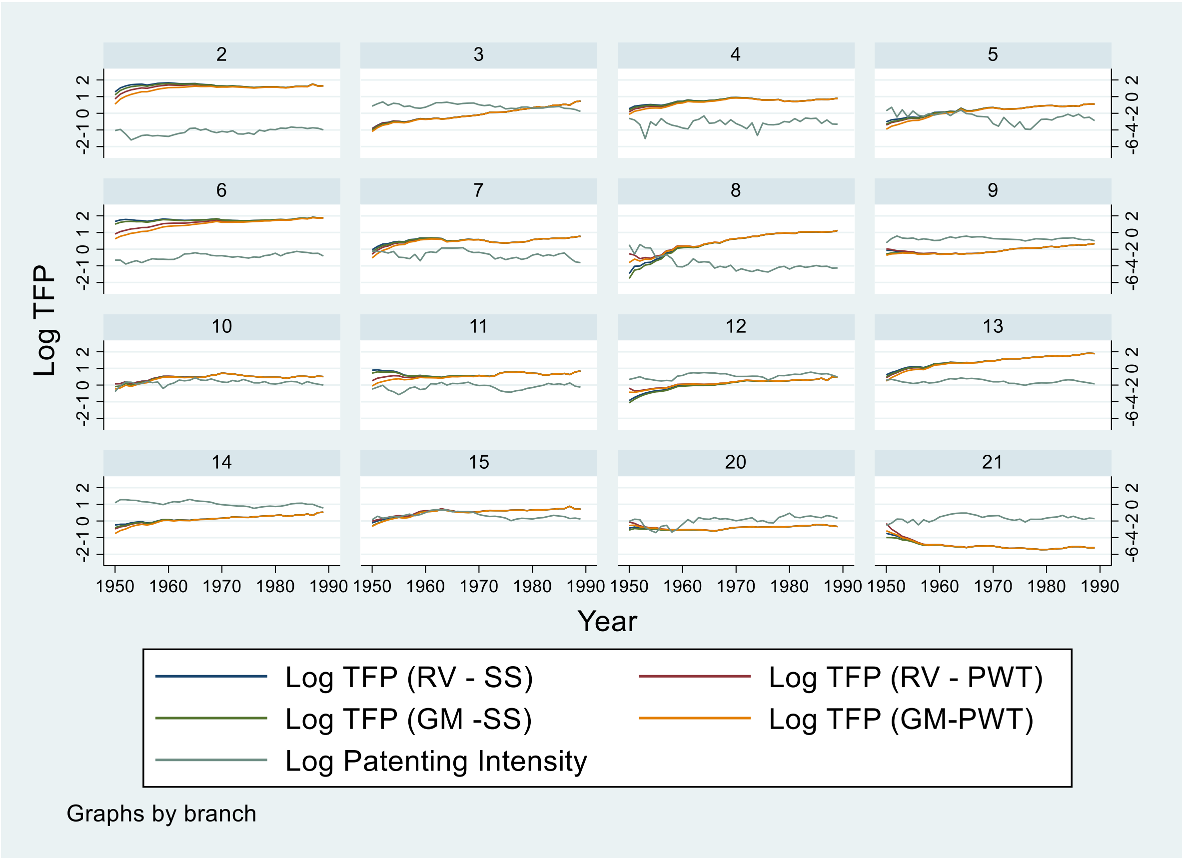
Source: Heske 2013, Glitz and Meyersson 2020, Ritschl and Vonyó 2014, own calculations.[101]

As shown in Figure 4, the differences of TFP in the entire economy between both datasets do not appear large at first glance. But Figure 5, which relates the different TFP series to patenting intensity, reveals that some sectors are strongly affected. Log figures are used in order to make short-term differences more easily apparent – particularly the patent series appear extremely smooth in level terms but actually show a high degree of variation over time when examining the logged series. From the figure three major findings are apparent: firstly, that the TFP series rapidly converge, independent of initial capital stocks, suggesting a robustness of the approach that is confirmed by regressions run on the different series. Secondly, there is substantial difference across

[101] Heske, 'Value Added, Employment and Capital Expenditures in the East German Industry, 1950-2000'; Glitz and Meyersson, 'Industrial Espionage and Productivity'; Ritschl and Vonyó, 'The Roots of Economic Failure'.

sectors: some have generally higher productivity than patent intensity, while some have generally lower patent intensities. Finally, the temporal relationship between patenting intensities differs: whereas the trends go in the same direction in some sectors, they go in the opposite direction in others. Given the earlier exploration of differences in patenting activity by sector, this is not wholly unsurprising given the inherent differences in patenting intensities across sectors discussed earlier. Ultimately, I am confident that my TFP series is a substantial improvement on the series employed by GM2020 since it substitutes empirical study of the GDR's capital stock for relatively crude estimation techniques.

<u>Figure 5: Different sectoral log TFP series and log Patents/Gross Value Added</u>



Source: Heske 2013, Glitz and Meyersson 2020, Ritschl and Vonyó 2014, own calculations.[102] Patenting Intensity is defined as the number of patent applications divided by gross value added.

---

[102] Heske, 'Value Added, Employment and Capital Expenditures in the East German Industry, 1950-2000'; Glitz and Meyersson, 'Industrial Espionage and Productivity'; Ritschl and Vonyó, 'The Roots of Economic Failure'.

Other Data

In addition to the panel data employed for a direct verification of GM2020's approach, I have also found material on education levels, investments in research and development, I have also drawn on reports on the conditions of the R&D establishment in the GDR. Unfortunately, these are not suited to being incorporated in the regression analysis because they are either spotlight reports on matters within a single year or they are time series with large and irregular gaps. Due to these shortcomings, I will touch on this material in my discussion of the main results to contextualise the findings but will not introduce it at length here.

Methodology

My methodology is oriented significantly on the approach used Glitz and Meyersson in GM2020, namely employing panel data analysis to identify relationships over time.[103] In the earlier literature review, I have explored the many ways in which patenting is linked towards productivity, both because of the direct transmission of knowledge through patents and the know-how acquired in the process of generating a patentable invention. As such, all other things being equal, a period with a larger number of patent applications may be followed by a period of relatively faster productivity growth. While company-specific know-how being gained might be instantaneous (or even precede the patent application), knowledge spillovers can only occur after the knowledge contained in the patent is made public through the application, and implementation might add a further delay. As such, the interval for the differencing of the dependent variable is chosen as three years.

As mentioned in the literature review, predictions of productivity are often implemented by first calculating a patent stock as a proxy for the stock of knowledge. For several reasons, this is impractical in the case of the GDR, so instead the number of patent applications is used as a variable to describe

[103] Glitz and Meyersson, 'Industrial Espionage and Productivity'.

additions to the stock of knowledge. This implicitly assumes a depreciation rate of zero for the knowledge stock, an assumption also made in the GM2020 model, based on the findings of Griliches and Lichtenberg, who determined that models using the zero-depreciation assumption worked well in predicting American TFP across industries.[104] Moreover, the future trajectory of TFP is crucially determined by current TFP: the more productive a sector is already, the more difficult it is to create additional TFP growth. As such, the regression model is specified as in Equation 4:

$$\Delta lnTFP_{jt+3} = \beta \times lnP_{\mathrm{jt}} - \gamma \times lnTFP_{jt} + \lambda_j + \pi_{t+3} + \epsilon_{jt+3} \qquad 4$$

In which the difference in log TFP at time $t + 3$ is predicted from the logged patenting intensity P_{jt} and the logged TFP at time t. To account for the different patenting intensities for each sector, the sector fixed effects λ_j are also added, and to account for the potential of technological improvements that do not differ by sector, the year fixed effects π_{t+3} are added.

The three-year gap leads to overlapping windows, which requires a new calculation of the standard errors to account for this artificial serial correlation. This can be solved by calculating p-values using the bootstrap-based t-procedure proposed by Cameron, Gelbach and Miller (2008) because it weeds out this artificial correlation.[105] It works by creating "pseudo-samples" from the data to calculate the actual distribution of the statistic of interest in the sample by analysing the value of the statistic of interest in the pseudo-samples.[106]

104 Glitz and Meyersson; Griliches and Lichtenberg, 'R and D and Productivity at the Industry Level'.

105 Cameron, Gelbach, and Miller, 'Bootstrap-Based Improvements for Inference with Clustered Errors'; Glitz and Meyersson, 'Industrial Espionage and Productivity', 1074–75.

106 Cameron, Gelbach, and Miller, 'Bootstrap-Based Improvements for Inference with Clustered Errors', 416.

Empirical results

Replication of Glitz and Meyersson

The first step I took based on my concerns with the comparability of data between the GDR and FRG in the GM2020 paper was to run the same regressions with my own dataset. In theory, to approach the same question using data that is prepared in the same way for both countries should provide more reliable results. The AfEP data on yearly patent applications of Kombinate used in GM2020 does not contain any patents from foreign firms, which as has been demonstrated in the historiography section were vital suppliers of technology to the GDR in several key areas in which the GDR was weak. Moreover, it does not contain any patents applied for by private inventors. As such, it might be considered a dataset of patents of major businesses rather than a dataset of GDR patenting more generally.

Table 4: Regression results using the AfEP and DEPATISnet data

	Own Data		GM2020 Data	
	Patents gap	Lagged TFP gap	Patents gap	Lagged TFP gap
Espionage	-0.0420*	-0.0481+	-0.0405*	-0.0523+
	(-1.93)	(-4.23)	(-1.95)	(-4.33)
Patents Gap	0.0743**	-0.0815**	0.0708**	-0.0381
	(2.46)	(-2.26)	(2.54)	(-1.58)
Log TFP Gap		-0.602+		-0.5644+
		(-5.87)		(-6.26)
P-value WB	0.109	0.025	0.128	0.0106
R-squared	0.352	0.570	0.355	0.564
Observations	240	240	240	240

t statistics in parentheses
* p<0.10, ** p<0.05, *** p<0.01, + p<0.001

Table 4 demonstrates the results obtained by replicating the GM2020 method using my own patent series: Regressing the gap in the TFP between East and West Germany on independent variables that are lagged by three years, adding year and sector fixed effects and clustering standard errors at the sectoral level. The results are striking: where in GM2020, the inclusion of the lagged TFP gap removes the significance of the lagged patent gap and leaves only the inflows of industrial espionage and the lagged TFP as significant explanatory variables, the results are remarkably different when using the DEPATISnet data: when regressing the TFP gap on lagged espionage and patents and controlling for the lagged TFP gap, the coefficient for the patent gap becomes negative and remains significant at the 5%-level. Not only that, but its magnitude is also twice as high as that of the inflows of industrial espionage (although granted, the latter is far more significant, at the 0.1% level).

While significance alone is of course not everything, the fact that the coefficient for the patent gap is twice as high as that for espionage is quite remarkable. Of course, this would not be much of a concern – it would in fact be rather delightful to find an additional statistically significant coefficient so quickly for the variable of interest. However, the coefficient is *negative*. This means that the empirical model employed by Glitz and Meyersson predicts that patents in the GDR actually *hurt productivity* – since a larger patent gap would be associated with a smaller productivity gap.

The relationship holds when subjected to the same robustness checks as employed by Glitz and Meyersson, which includes several instrumental variable approaches that seek to remove confounding errors.

Single-country investigations

Table 5: Single-Country Results - FRG

	(1) Log TFP Growth	(2) Log TFP Growth
Log Patents/GVA	0.146+	0.0715**
	(4.95)	(2.73)
Log TFP		-0.275**
		(-2.87)
P-value WB	0.00100	0.0831
Adj. R-Squared	0.306	0.384
Observations	272	272

t statistics in parentheses
* p<0.10, ** p<0.05, *** p<0.01, + p<0.001

In Table 5, the results for a regression of logged TFP on three-year lagged patenting activity is presented, with and without controlling for three-year lagged TFP are presented. As described above, the regression uses year and sector fixed effects and standard errors clustered at the sectoral level.
The coefficients for the FRG are around what would be expected: there is a positive coefficient of lagged patent applications on TFP, which becomes less significant and smaller when controlling for lagged TFP. The coefficient for log TFP is negative, as would be predicted. This may have several reasons: Firstly, it may reflect international catch-up to the technology frontier, which is slower in higher-productivity sectors with less scope for catch-up growth. Secondly, it may simply reflect a tendency towards diminishing returns. At least for the FRG, findings are thus broadly in line with what would be expected given the link between patenting and productivity discussed earlier.

As such, this same regression model is now applied in the GDR, and the results are reported in Table 6.

Table 6: Single-Country Results – GDR (GM TFP series)

	(1) Log TFP Growth	(2) Log TFP Growth
Log Patents/GVA	0.104+	0.00362
	(4.60)	(0.30)
Log TFP		-0.211+
		(-5.37)
P-value WB	0.117	0.757
Adj. R-Squared	0.668	0.742
Observations	592	592

t statistics in parentheses
* p<0.10, ** p<0.05, *** p<0.01, + p<0.001

Here, the results are quite different. When not controlling for logged TFP, the coefficient of patents is highly significant at the 0.1% level, and it is two orders of magnitude larger than in the FRG – but this impression is quickly overturned when considering the Wild Bootstrap p values, according to which the coefficient is not significant at the 10% level. Once the control is introduced, the coefficient on patents is completely non-significant, even though the number of observations is more than twice as high.

Table 7: Single-Country Results – GDR (Ritschl and Vonyó TFP series – Steady State)

	(1)	(2)
	Log TFP Growth	Log TFP Growth
Log Patents/GVA	0.0967+	-0.000792
	(5.11)	(-0.07)
Log TFP		-0.211+
		(-4.59)
P-value WB	0.0951	0.945
Adj. R-Squared	0.592	0.678
Observations	592	592

t statistics in parentheses
* p<0.10, ** p<0.05, *** p<0.01, + p<0.001

As shown in Table 7, these results are broadly confirmed when using the RV TFP series in which initial capital stocks are assigned based on the Caselli steady state method – the coefficient on log TFP in specification 2 is even of the exact same magnitude as in the GM TFP series.

Table 8: Single-Country Results – GDR (Ritschl and Vonyó TFP series – PWT)

	(1)	(2)
	Log TFP Growth	Log TFP Growth
Log Patents/GVA	0.00204	-0.0913***
	(0.15)	(-3.28)
Log TFP		-0.337+
		(-6.85)
P-value WB	0.856	0.0450
Adj. R-Squared	0.287	0.488
Observations	592	592

t statistics in parentheses
* p<0.10, ** p<0.05, *** p<0.01, + p<0.001

Table 8 shows the regression results when using the Ritschl TFP series with the PWT-method giving equal capital-output ratios to each sector. With this series, there is again a surprising outcome because the coefficient of patenting on log TFP growth in specification 2 is negative and highly significant. However, this is driven by sector 8, meaning to coke production and oil refining, whose capital stock is undervalued given the PWT method – hardly surprising, considering the substantial Nazi-era investments into the refineries in Leuna, which would continue providing a backbone to the GDR's petrochemical industry. Results without sector 8 are reported in Table A 6.

When adding controls such as the number of collaborators or a further lag of the dependent variable, the results are not substantially changed. Thus, in conclusion, there appears to be no statistically significant relationship between a sector's TFP growth and earlier patenting activity when accounting for the level of TFP.

Discussion

The results of the regressions clearly show that in the GDR, patent applications are not a suitable indicator of innovative activity that is transmitted into productivity growth – mostly irrespective of the measure of productivity that is employed. This stands in contrast with the FRG, and stands in contrast with the results obtained by Glitz and Meyersson. I argue that there are fundamentally two factors that lead to this non-significant result: firstly, the amount or quality of "innovative knowledge" contained within each patent were lower. Secondly, the "innovative knowledge" contained within the patent was not generally applied and so did not spread throughout the economy. The first aspect does provide an interesting avenue of further research: further information on patents in the GDR does exist, even though it is in paper archives and difficult to access. However, the second aspect is arguably more interesting in terms of our fundamental research question, because it is inherently tied into the valuation of patents itself!

Some reasons why patents may have been of lower "quality" in the GDR are the planning of innovation, the working conditions of inventors, and the incentives inherent in the patenting system itself. Innovation was part of the GDR's economic plan from the very beginning, and this is reflected in the attention that top-level politicians lavished on various technological "Wunderwaffen". Unfortunately for them, this chasing of miracle cures was not effective, and neither was the innovation planning system more generally. This was due to the classic information problem common to all economic planners, who simply cannot knoe all they need to know to effectively make forward-looking economic plans. As such, research problems were often behind the global "state of the art" and had to be aborted or changed frequently, and projects that were carried out often merely replicated what had already been achieved elsewhere.[107] Additionally, working conditions were suboptimal – while the number of researchers was relatively high (even higher than in the FRG relative to the number of employees) they did not have access to adequate support staff or technical equipment.[108] Expenditure on R&D also made up only half as large of a share of turnover in the GDR as in the FRG.[109]

Secondly, the patent system itself created incentives for over-patenting. Patents were essentially free, which meant that there was very little harm in attempting to receive a patent on inventions even of dubious value – and neither was there a reason not to split a collection of related inventions into multiple patents. At the same time, there were rewards for patenting: they were lower than in a market economy, but still existed in the form of monetary rewards and civil honours. There was also no reason to fear that other firms would "work around" the patent and erode the rightsholder's market share in a planned economy. Trends in overall patenting intensity are erratic as seen in Figure 6, which makes it less likely that there was a consistent loosening of requirements over time to meet plan goals.

---

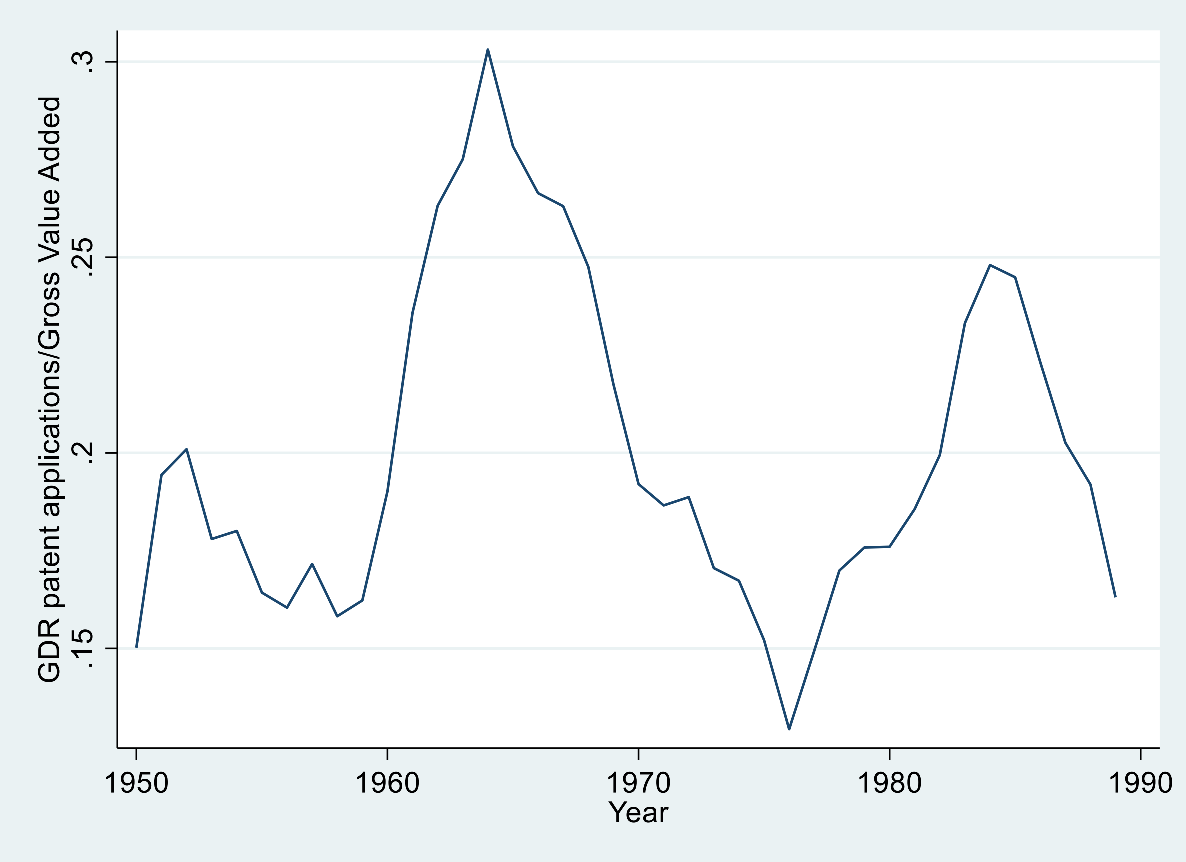
[107] Lindig, 'Ausgewählte Rahmenbedingungen Des Erfinderischen Schaffens in Der DDR', 23.
[108] Lindig, 10.
[109] Bentley, *Research and Technology in the Former German Democratic Republic*, 180.

Generally, then, there are many reasons to believe that the average patent in the GDR had a lower economic value than in other countries, such as the FRG. However, there exists a substantial amount of data on the economic application of patents in the GDR, and researchers who recover and analyse it might find an interesting avenue of further research on the specifics of patenting in the GDR.

Of course, the other factor is the generally lower performance of planned economies in implementing innovations (this also fundamentally drives the "value" or "quality" of the patent itself, of course). The results of the analysis might cautiously be interpreted as a confirmation of the anecdotal evidence on the refusal or inability to implement state-of-the-art manufacturing techniques, like for example in the microelectronics industry, where this problem held up high-level research for years.[110] Even in the case of innovations generated by in-house R&D programmes, there were strong forces at play against their implementation, partially because there was a great deal of siloing between R&D and production staff and there was practically no expectation for production staff to implement novelties. Interestingly, one way that inventors sought to overcome this was apparently to put their bosses down as co-inventors to align their incentives with the uptake of the patent.[111] Finally, as noted above, the GDR had suffered from an outflow of human capital before the building of the wall, which reduced the number of people who would be able effectively use knowledge as a factor of production. In a time series analysis in which national productivity trends are regressed on national patenting activity and controlling for the share of graduates as well as past TFP, there is in fact a positive significant coefficient on both patenting and the share of graduates – but this result is simply a result of the non-stationarity of our TFP growth variable (which trends downwards) and our graduate share variable (which trends upwards) and disappears when employing first-differences.

[110] Augustine, *Red Prometheus*, 126.
[111] Lindig, 'Ausgewählte Rahmenbedingungen Des Erfinderischen Schaffens in Der DDR', 55.

Figure 6: Patent Applications/Gross Value Added in the GDR



Data Source: DEPATISnet, Heske (2013)

Overall, my hypothesis that the relationship between patenting and productivity is less strongly positive in the GDR than in other countries, but still positive, could not be confirmed by the regression results when drawing on the entire country's patent stock. This is itself a fascinating result, as it suggests that the institutional structure of the GDR's innovation system was set up in a seriously suboptimal way: patents as a critical element of the innovative process did not fulfil their purpose of creating a stock of useful knowledge to be disseminated through the economy, generally speaking.

However, the historical record provides several clues that further research on how the transmission of patenting activity into productivity worked in the GDR would be fruitful. One approach is valuing the patents to identify the subset of patents that were particularly useful. Potential approaches include taking advantage of the national-level data on patents' implementation from the AfEP archives or company-level data on R&D staffing, investment, patenting, and productivity. Another approach, which was planned for this thesis but impossible to implement due to issues of data availability, quality, and consistency, is to investigate the difference between firm-level and national-level political pressure on researchers: for example, recall the political interference in the microelectronics research establishment. Or consider the differences in the Stasi's power between the different chemical Kombinate. By contrasting company-level political interference with interference on a national level, valuable insights might be gained into the mechanisms by which politically repressive systems degrade their economies' ability to innovate, which would have contemporary relevance to authoritarian countries such as China.

Concluding Remarks

In this thesis I have attempted to answer the research question "what was the relationship between patenting and productivity in the GDR" by adapting an econometric model from the literature and applying it my own time series on patent data and TFP in order to increase the timeframe of the analysis and enhance the robustness of the results. To do so, I have introduced some literature on the link between patents and productivity more generally, as well as specifics to consider in the context of a planned economy. I then related these specificities to the GDR's historiography, leading me to two conclusions and my hypothesis: firstly, I conclude that the planned economy in the GDR reduced the tendency for innovations to be transmitted across the economy and implemented in improved products and production. Secondly, patents in the GDR likely provide a more direct measure of R&D activity than elsewhere because its costs are so low – but this tends to increase the share of economically useless patents. As such, my hypothesis follows: the relationship between patenting and productivity in the GDR is likely to be smaller than elsewhere but still positive.

This hypothesis is tested empirically using a dynamic panel regression on productivity growth and patenting in the GDR, and cannot be confirmed: using the entirety of the GDR's patent stock, no statistically significant link between patenting and productivity could be established once controlling for past TFP. This is true regardless of the TFP series used. When compared to the historical record, it suggests that the hypothesis was too optimistic, likely because of the low economic usefulness of the average GDR patent. Data sources that exist, but could not be exploited for this thesis, such as AfEP data on the actual use of patents or historical company accounts, could provide an avenue for further fruitful study. In fact, the original vision for this research project was to undertake a difference-in-difference analysis on the effects of Stasi replacement of R&D executives at important GDR innovators. It could not be implemented because of challenges in reliably assigning patents to economic entities and the difficulty of accessing German paper archives during covid – but such research might allow further understanding of political interference as a brake on innovation in authoritarian systems.

References

Allen, Robert C. 'The Rise and Decline of the Soviet Economy'. *The Canadian Journal of Economics / Revue Canadienne d'Economique* 34, no. 4 (2001): 859–81.

Augustine, Dolores L. 'Management of Technological Innovation: High Tech R&D in the GDR'. *Business History* 0, no. 0 (27 December 2020): 1–17. https://doi.org/10.1080/00076791.2020.1848489.

———. Red Prometheus: Engineering and Dictatorship in East Germany, 1945-1990. Transformations. Cambridge, Mass: MIT Press, 2007.

———. 'The Failure of the East German Electronics Industry'. In *The East German Economy, 1945–2010 Falling Behind or Catching Up?*, edited by Edited Hartmut Berghoff and Uta Andrea Balbier. Cambridge: Cambridge University Press, 2013.

Bentley, Raymond. Research and Technology in the Former German Democratic Republic. Boulder, Colo: Westview Press, 1992.

Broadberry, Stephen, and Alexander Klein. 'When and Why Did Eastern European Economies Begin to Fail? Lessons from a Czechoslovak/UK Productivity Comparison, 1921–1991'. *Explorations in Economic History* 48, no. 1 (1 January 2011): 37–52. https://doi.org/10.1016/j.eeh.2010.09.001.

Burhop, Carsten. 'The Transfer of Patents in Imperial Germany'. *The Journal of Economic History* 70, no. 4 (December 2010): 921–39. https://doi.org/10.1017/S002205071000077X.

Buthmann, Reinhard. *Versagtes Vertrauen: Wissenschaftler Der DDR Im Visier Der Staatssicherheit*. Göttingen: Vandenhoeck & Ruprecht, 2020. http://ebookcentral.proquest.com/lib/londonschoolecons/detail.action?docID=6264508.

Cameron, A. Colin, Jonah B. Gelbach, and Douglas L. Miller. 'Bootstrap-Based Improvements for Inference with Clustered Errors'. *Review of Economics and Statistics* 90, no. 3 (August 2008): 414–27. https://doi.org/10.1162/rest.90.3.414.

Caselli, Francesco. 'Chapter 9 Accounting for Cross-Country Income Differences'. In *Handbook of Economic Growth*, edited by Philippe Aghion and Steven N. Durlauf, 1:679–741. Elsevier, 2005. https://doi.org/10.1016/S1574-0684(05)01009-9.

Chiang, Jong-Tsong. 'Management of Technology in Centrally Planned Economies'. *Technology in Society* 12, no. 4 (January 1990): 397–426. https://doi.org/10.1016/0160-791X(90)90012-2.

Cubel, Antonio, and Vicente Esteve. 'The Effect of Foreign and Domestic Patents on Total Factor Productivity during the Second Half of the 20th Century'. DOCUMENTOS DE TRABAJO. Universidad de Alcala, June 2014.

Dale, Gareth. Between State Capitalism and Globalisation: The Collapse of the East German Economy. Oxford : New York: Peter Lang, 2004.

Fengler, Silke. 'Innovation in a Centrally Planned Economy: The Case of the Filmfabrik Wolfen'. In *The East German Economy, 1945–2010 Falling*

Behind or Catching Up?, edited by Edited Hartmut Berghoff and Uta Andrea Balbier. Cambridge: Cambridge University Press, 2013.
Förtsch, Eckart. 'Wissenschafts- und Technologiepolitik in der DDR'. In *Naturwissenschaft und Technik in der DDR*, edited by Dieter Hoffmann and Kristie Macrakis. Berlin: Akademie Verlag, 1997.
Franzmann, Gabriele. 'Berufsausbildung Und Studium in Der Ehemaligen Deutschen Demokratischen Republik (DDR) von 1960 Bis 1989. Ein Überblick Anhand Der Amtlichen DDR-Statistik.' Köln: GESIS Datenarchiv, 2006.
———. 'Bevölkerung in Der Ehemaligen DDR 1946-1989'. Köln: GESIS Datenarchiv, 2007.
Glitz, Albrecht, and Erik Meyersson. 'Industrial Espionage and Productivity'. *American Economic Review* 110, no. 4 (April 2020): 1055–1103. https://doi.org/10.1257/aer.20171732.
Griffith, Rachel, Stephen Redding, and John Van Reenen. 'Mapping the Two Faces of R&D: Productivity Growth in a Panel of OECD Industries'. *Review of Economics and Statistics* 86, no. 4 (November 2004): 883–95. https://doi.org/10.1162/0034653043125194.
Griliches, Zvi, and Frank R. Lichtenberg. 'R and D and Productivity at the Industry Level: Is There Still a Relationship?' Working Paper. Working Paper Series. National Bureau of Economic Research, February 1982. https://doi.org/10.3386/w0850.
Hall, Bronwyn H., Adam Jaffe, and Manuel Trajtenberg. 'Market Value and Patent Citations'. *The Rand Journal of Economics* 36, no. 1 (Spring 2005): 16–38.
Heske, Gerhard. 'Value Added, Employment and Capital Expenditures in the East German Industry, 1950-2000: Data, Methods, Comparisons ; an Introduction'. *Historical Social Research* 38, no. 4 (2013): 7–13. https://doi.org/10.12759/hsr.38.2013.4.7-13.
Horstmann, Ignatius, Glenn M. MacDonald, and Alan Slivinski. 'Patents as Information Transfer Mechanisms: To Patent or (Maybe) Not to Patent'. *Journal of Political Economy* 93, no. 5 (October 1985): 837–58. https://doi.org/10.1086/261338.
Inklaar, Robert, and Marcel P. Timmer. 'Capital, Labor and TFP in PWT8.0'. Groningen: Groningen Growth and Development Centre, University of Groningen, 2013. https://www.rug.nl/ggdc/docs/capital_labor_and_tfp_in_pwt80.pdf.
Karlsch, Rainer. Allein Bezahlt? Die Reparationsleistungen Der SBZ/DDR 1945-53. 1. Aufl. Berlin: C. Links, 1993.
Kogut, Bruce, and Udo Zander. 'Did Socialism Fail to Innovate? A Natural Experiment of the Two Zeiss Companies'. *American Sociological Review* 65, no. 2 (2000): 169–90. https://doi.org/10.2307/2657436.
Laitko, Hubert. 'Das Reformpaket der sechziger Jahre - wissenschaftspolitisches Finale der Ulbricht-Ära'. In *Naturwissenschaft und Technik in der DDR*, edited by Dieter Hoffmann and Kristie Macrakis. Berlin: Akademie Verlag, 1997.

Lindig, Dieter. ‘Ausgewählte Rahmenbedingungen Des Erfinderischen Schaffens in Der DDR’, 1995. http://biss.bplaced.net/downloads/BISS%20FH%209-95.pdf.
Macrakis, Kristie. ‘Das Ringen um den technischen Höchststand: Spionage und Technologietransfer in der DDR’. In *Naturwissenschaft und Technik in der DDR*, edited by Dieter Hoffmann and Kristie Macrakis. Berlin: Akademie Verlag, 1997.
Motohashi, Kazuyuki. ‘Licensing or Not Licensing? An Empirical Analysis of the Strategic Use of Patents by Japanese Firms’. *Research Policy* 37, no. 9 (1 October 2008): 1548–55. https://doi.org/10.1016/j.respol.2007.12.014.
Nagaoka, Sadao, Kazuyuki Motohashi, and Akira Goto. ‘Patent Statistics as an Innovation Indicator’. In *Handbook of the Economics of Innovation*, 2:1083–1127. Elsevier, 2010. https://doi.org/10.1016/S0169-7218(10)02009-5.
Naudé, Wim, and Paula Nagler. ‘Technological Innovation, Entrepreneurship and Productivity in Germany, 1871-2015’. SSRN Scholarly Paper. Rochester, NY: Social Science Research Network, 4 January 2018. https://doi.org/10.2139/ssrn.3107759.
Pakes, Ariel, and Zvi Griliches. ‘Patents and R and D at the Firm Level: A First Look’. Working Paper. Working Paper Series. National Bureau of Economic Research, October 1980. https://doi.org/10.3386/w0561.
Plant, Arnold. ‘The Economic Theory Concerning Patents for Inventions’. *Economica* 1, no. 1 (February 1934): 30. https://doi.org/10.2307/2548573.
Ritschl, Albrecht O. ‘An Exercise in Futility: East German Economic Growth and Decline, 1945–89’. In *Economic Growth in Europe since 1945*, edited by Nicholas Crafts and Gianni Toniolo, 1st ed., 498–540. Cambridge University Press, 1996. https://doi.org/10.1017/CBO9780511758683.017.
Ritschl, Albrecht, and Tamás Vonyó. ‘The Roots of Economic Failure: What Explains East Germany’s Falling behind between 1945 and 1950?’ *European Review of Economic History* 18, no. 2 (1 May 2014): 166–84. https://doi.org/10.1093/ereh/heu004.
Schankerman, Mark, and Ariel Pakes. ‘Estimates of the Value of Patent Rights in European Countries During the Post-1950 Period’. *The Economic Journal* 96, no. 384 (1986): 1052–76. https://doi.org/10.2307/2233173.
Schiefer, Mark. *Profiteur Der Krise: Staatssicherheit Und Planwirtschaft Im Chemierevier Der DDR 1971–1989*. Gottingen, GERMANY: Vandenhoeck & Ruprecht, 2018. http://ebookcentral.proquest.com/lib/londonschoolecons/detail.action?docID=5355206.
SPIEGEL, DER. ‘DDR-Spionage: »Das läßt die mächtig wackeln«’. *Der Spiegel*. 4 September 1979, 10/1979 edition.
Stokes, Raymond G. ‘East Germany and the Oil Crises of the 1970s’. In *The East German Economy, 1945–2010 Falling Behind or Catching Up?*, edited by Edited Hartmut Berghoff and Uta Andrea Balbier, 260. Cambridge: Cambridge University Press, 2013.
———. ‘Von Trabbi Und Acetylen - Die Technikentwicklung’. In *Überholen Ohne Einzuholen: Die DDR-Wirtschaft Als Fussnote Der Deutschen*

Geschichte?, edited by André Steiner, 1. Aufl. Forschungen Zur DDR-Gesellschaft. Berlin: Links, 2006.
Streb, Jochen, Jörg Baten, and Shuxi Yin. 'Technological and Geographical Knowledge Spillover in the German Empire 1877-1918'. *The Economic History Review* 59, no. 2 (2006): 347–73.
Verspagen, Bart, Ton van Moergastel, and Maureen Slabbers. 'MERIT Concordance Table: IPC - ISIC (Rev. 2)'. MERIT Research Memorandum. Maastricht: Maastricht Economic Research Institute on Innovation and Technology, 1994.
Vonyó, Tamás. 'War and Socialism: Why Eastern Europe Fell behind between 1950 and 1989†'. *The Economic History Review* 70, no. 1 (2017): 248–74. https://doi.org/10.1111/ehr.12336.
Wiessner, Matthias. 'Das Patentrecht der DDR'. In *Geschichte des deutschen Patentrechts*, edited by Martin Otto and Diethelm Klippel. Geistiges Eigentum und Wettbewerbsrecht 102. Tübingen: Mohr Siebeck, 2015.
Wisła, Rafał. 'Patent Data in Economic Analysis'. In *Intellectual Property Rights*, edited by Sakthivel Lakshmana Prabu and Timmadonu Narasimman Kuppusami Suriyaprakasha. InTech, 2017. https://doi.org/10.5772/68100.

Abbreviations

AfEP	Amt für Erfindungs- und Patentwesen - the patent office
DEPATISnet	Name of a German patent database
FRG	Federal Republic of Germany
GDR	German Democratic Republic
GM2020	Glitz and Meyersson - Industrial Espionage and Productivity - American Economic Review, 2020
MfS	Ministerium für Staatssicherheit, also known as the Stasi - the secret police
R&D	Research and Development
RV2014	Ritschl and Vonyó - The Roots of Economic Failure: What explains East Germany's Falling behind between 1945 and 1950? - European Review of Economic History, 2014
SED	Sozialistische Einheitspartei Deutschlands - the ruling party of the GDR
TFP	Total Factor Productivity

Appendix

Table A 1: Including the number of collaborators on a patent

	(1) c3ln_GDR_TFP_ritschl	(2) c3ln_GDR_TFP_ritschl
ln_GDR_patents_gva	-0.000593	-0.000592
	(-0.05)	(-0.05)
TFP	-0.209***	-0.208***
	(-3.86)	(-3.50)
ln_GDR_collabsize	-0.0109	
	(-0.17)	
GDR_collabsize		-0.00320
		(-0.20)
P-value WB	0.957	0.950
Adj. R-Squared	0.678	0.678
Observations	592	592

t statistics in parentheses
* p<0.10, ** p<0.05, *** p<0.01, + p<0.001

Table A 2: GDR, using first differences (GM TFP)

	(1) c3ln_GDR_TFP	(2) c3ln_GDR_TFP
D.ln_GDR_patents_gva	0.0000118	0.0308***
	(0.00)	(3.41)
D.TFP		0.526***
		(3.52)
P-value WB	1	0.00901
Adj. R-Squared	0.474	0.512
Observations	576	576

t statistics in parentheses
* p<0.10, ** p<0.05, *** p<0.01, + p<0.001

Table A 3: GDR, using first differences (Ritschl and Vonyo TFP series)

	(1) c3ln_GDR_TFP_ritschl	(2) c3ln_GDR_TFP_ritschl
D.ln_GDR_patents_gva	0.00290	0.0324***
	(0.31)	(3.69)
D.TFP		0.490**
		(2.88)
P-value WB	0.747	0.00501
Adj. R-Squared	0.422	0.458
Observations	576	576

t statistics in parentheses

* p<0.10, ** p<0.05, *** p<0.01, + p<0.001

Table A 4: FRG, using first differences

	(1) c3FRGlnTFP	(2) c3FRGlnTFP
D.ln_FRG_patents_gva	0.0387	-0.0398
	(1.39)	(-1.26)
D.ln_FRG_TFP		-0.770***
		(-3.51)
P-value WB	0.302	0.406
Adj. R-Squared	0.575	0.649
Observations	256	256

t statistics in parentheses

* p<0.10, ** p<0.05, *** p<0.01, + p<0.001

Table A 5: Including a strongly lagged dependent variable

	(1) c3ln_GDR_TFP	(2) c3ln_GDR_TFP
ln_GDR_patents_gva	0.0886***	-0.00370
	(3.04)	(-0.23)
l3c3ln_GDR_TFP	0.191*	0.0842
	(1.96)	(0.66)
ln_GDR_TFP		-0.229+
		(-5.04)
Adj. R-Squared	0.572	0.663
Observations	544	544

t statistics in parentheses

* p<0.10, ** p<0.05, *** p<0.01, + p<0.001

Table A 6: TFP using Ritschl and Vonyó series with flat weighting, excluding sector 8

	(1) c3ln_GDR_TFP_pwt_ritschl
ln_GDR_patents_gva	-0.0317
	(-1.18)
ln_GDR_TFP_pwt_ritschl	-0.295+
	(-4.18)
P-value WB	0.349
Adj. R-Squared	0.600
Observations	555

t statistics in parentheses

* p<0.10, ** p<0.05, *** p<0.01, + p<0.001

Table A 7: Including human capital variables

	(1) c3GDR_lnTFP_ritschl_total	(2) c3GDR_lnTFP_ritschl_total
GDR_ln_patents_gva_total	0.0581**	0.0628**
	(2.61)	(2.73)
ln_gradshare_total	0.143*	
	(1.94)	
TFP	-0.419*	-0.304
	(-2.00)	(-1.46)
ln_gradshare_nonservice		0.0712
		(1.39)
Adj. R-Squared	0.374	0.326
Observations	26	26