

# Perspectives on the knowledge economy from innovation history

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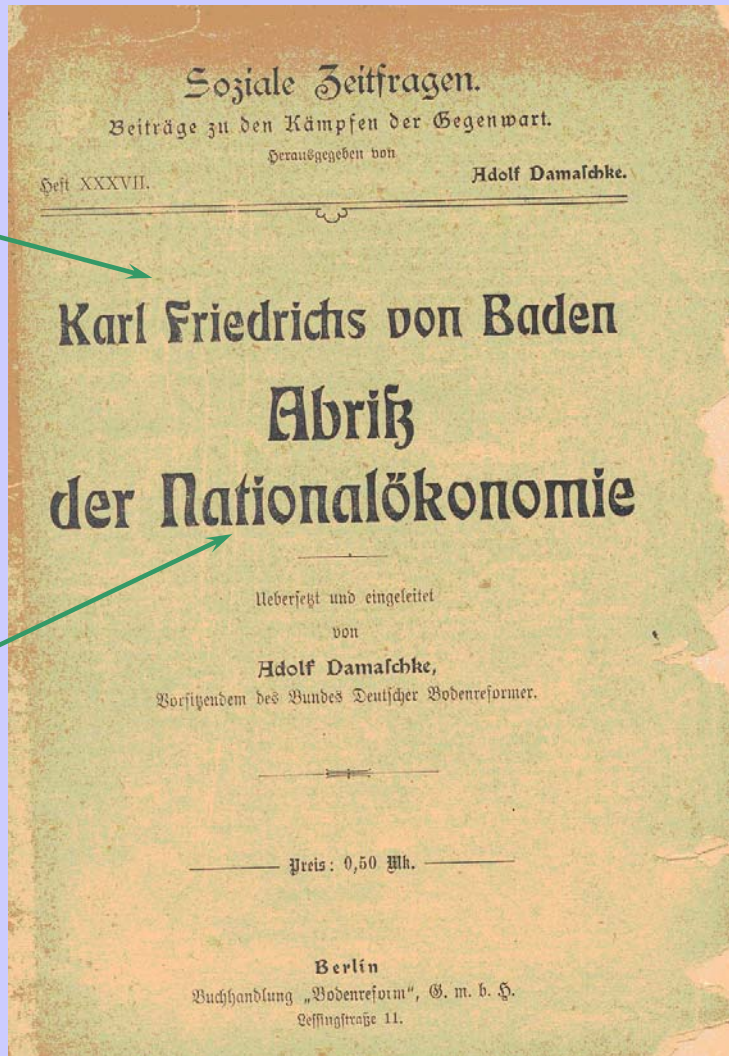
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## Here is an answer. What was the question?

- If we want to understand our modern system of technological change as an outcome of its evolution, we have to understand how it came about **historically**. This is an important task for historians of technology and economic historians, but not the prime concern in this contribution.
- Rather, we want to understand the **causality** between technological change, human capital, government subsidies for research and development and growing demand.
- Can we provide **evidence** how a national innovation system has reacted to structural changes? In times of globalisation and European integration: How will it likely react at the beginning of the 21<sup>st</sup> century?

# Why Germany?



Germany is an **ideal object of study** as it underwent many territorial and governance changes: it existed as a large array of individual states before 1871, was united 1871 from Alsace-Lorraine to East Prussia, reduced 1918 after World War I and split into the GDR and West Germany from 1949 to 1990. You can hardly imagine more external shocks to an innovation system.

# Methodological problems

- Over long periods one faces the problem of **changing definitions** of central terms.
- E. g.: In German textbooks in the late 19<sup>th</sup> century, R&D was termed „Discovery and Invention“, the first sector of the economy (**with six!**).
- Schumpeter coined the German word for „novelty (Neuheit)“ (1911) which was translated to English „**Innovation**“ and retranslated to the German identity only in the 1960ies.

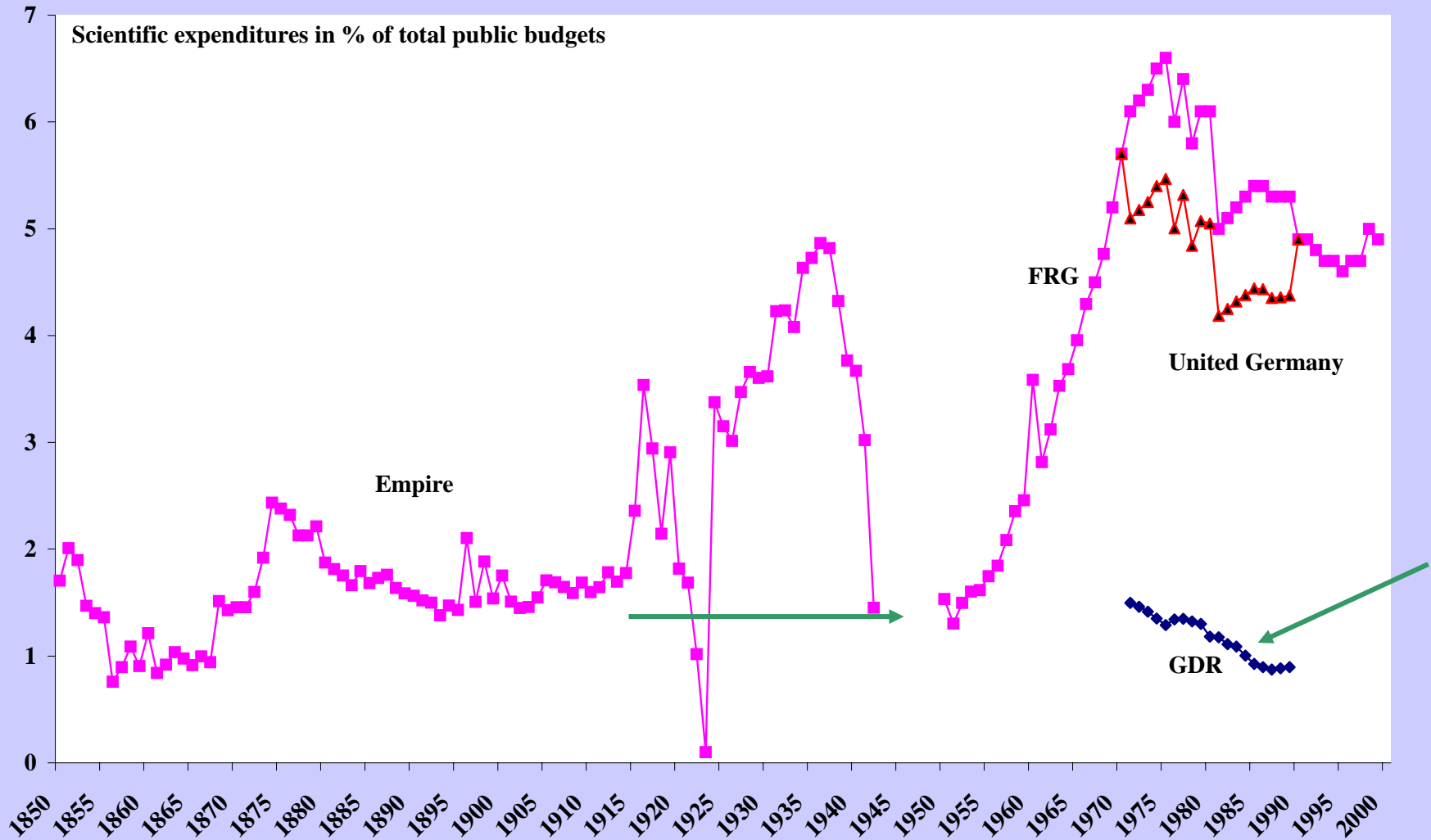
## Arbeit.

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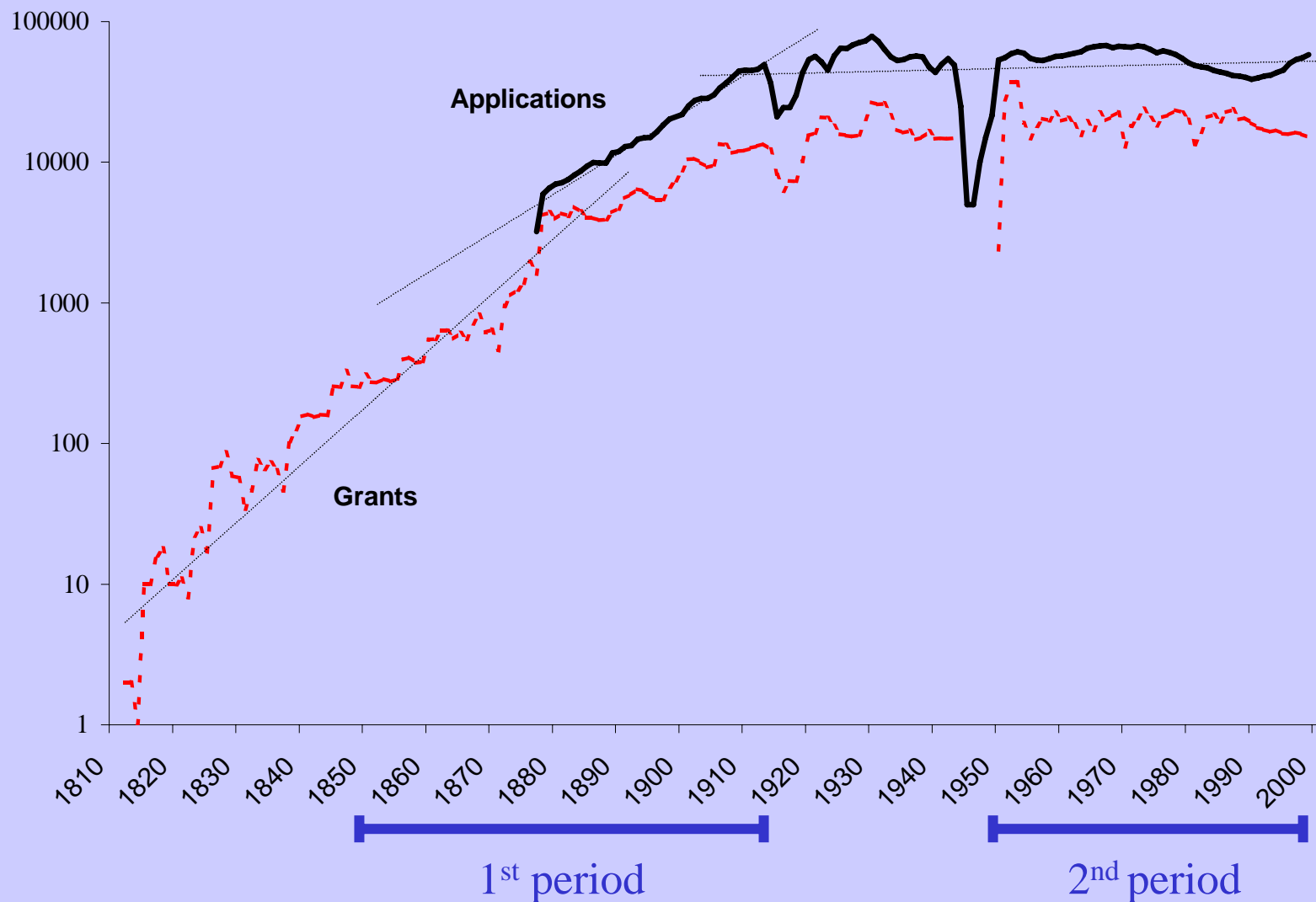
Die Fähigkeit des Menschen zu den meisten wirthschaftlichen Arbeiten<sup>1</sup> hängt so genau mit der feinen Gliederung der menschlichen Hand zusammen, daß Buffon ohne viel Uebertreibung sagen konnte, die Hand und die Vernunft machen den Menschen zum Menschen.<sup>2</sup> Doch gilt es von der wirthschaftlichen Arbeit, wie von jeder andern, daß sie um so wirksamer wird, je mehr der Geist in ihr über die Materie vorherrscht.

Alle wirthschaftlichen Arbeiten werden am besten in folgende Klassen getheilt:<sup>3</sup> A. Entdeckungen und Erfindungen.<sup>4</sup> B. Occupation der freiwilligen Naturgaben, wie der wilden Pflanzen, Thiere und Mineralien;<sup>5</sup> wo dieß noch die einzige Arbeit ist, da muß der Mensch in hohem Grade von der Natur abhängig sein. C. Rohproduction, d. h. Leitung der Natur, um brauchbare Rohstoffe hervorzubringen, wie z. B. durch Viehzucht, Ackerbau, Forstkultur zc., aber nicht im Mineralreiche. D. Rohstoffverarbeitung, wie sie den Fabriken, Manufacturen, Handwerken obliegt. E. Zutheilung des Gütervorrathes an diejenigen, welche unmittelbar davon Gebrauch machen wollen, sowohl von Nation zu Nation, Ort zu Ort (Großhandel), wie an die einzelnen Bewohner desselben Ortes (Kleinhandel).<sup>6</sup> Auch die Geschäfte des Pachtens, Miethens, Darleihens zc. gehören zu dieser Klasse. F. Dienstleistungen im engern Sinne, wozu wir nicht allein die Hervorbringung persönlicher, sondern überhaupt unkörperlicher Güter rechnen. Also z. B. die Arbeiten der Aerzte, Lehrer,

# Classical indicators of government subsidies: R&D budgets



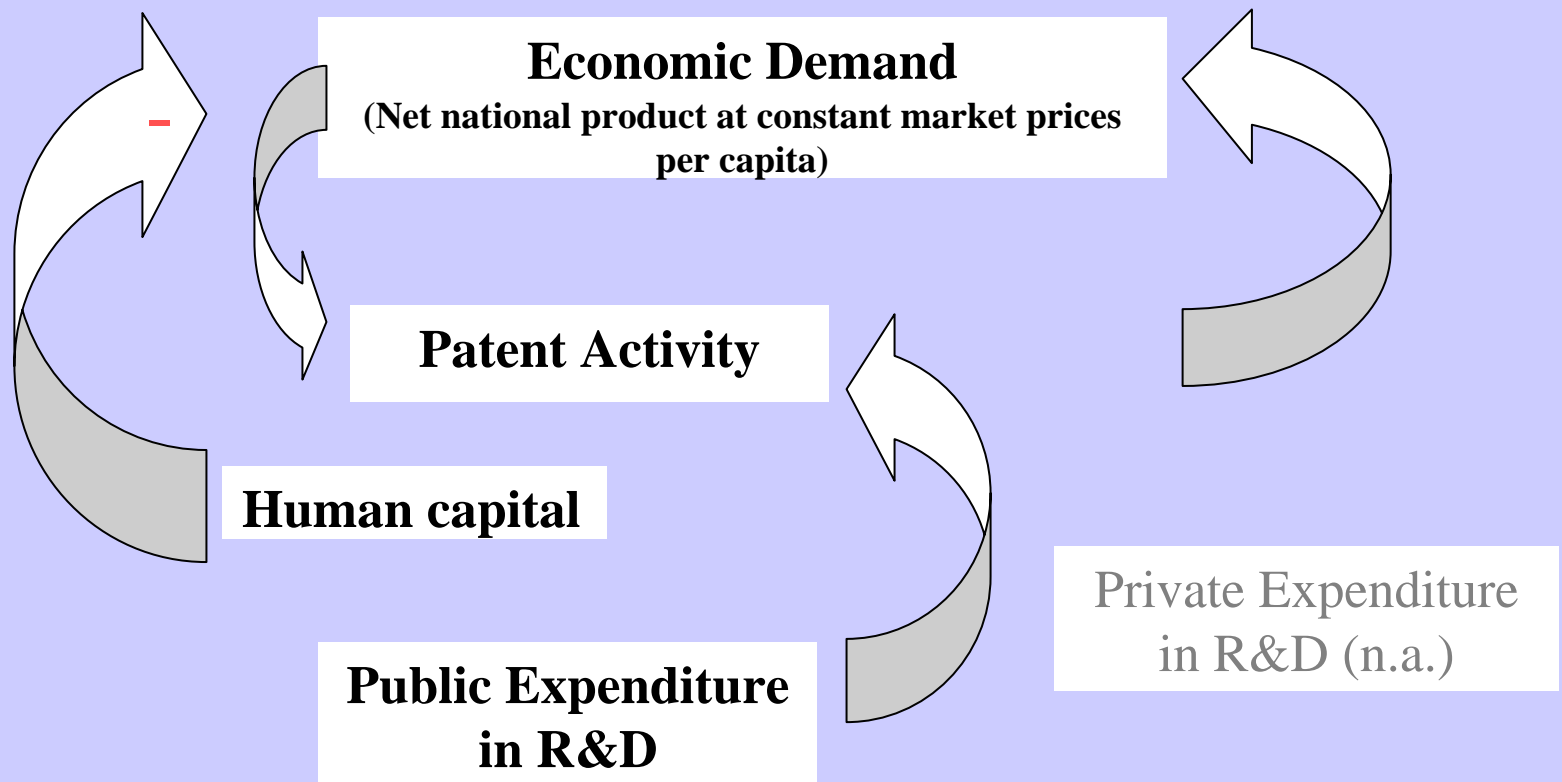
# Classical indicators of technical change: patents with exponential growth rates and ceiling



# Methodological procedure

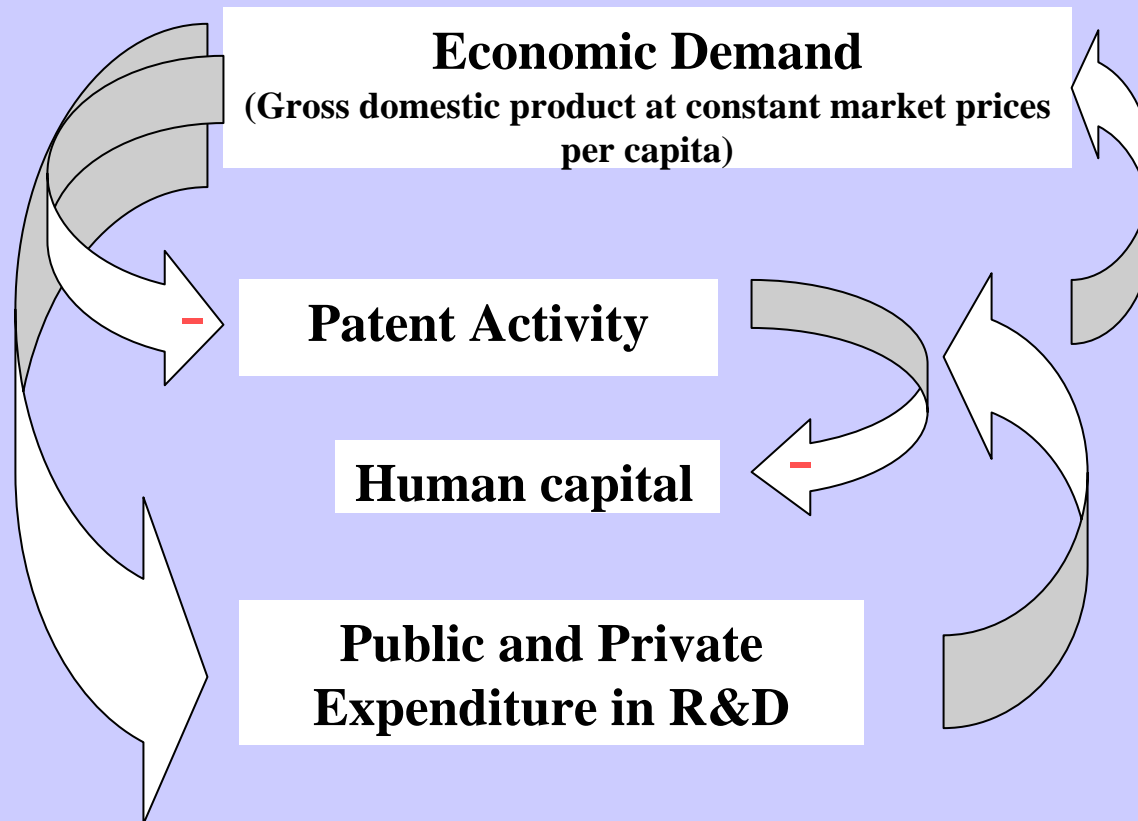
- We do **not** intend to define *a priori* any variable as endogenous. Instead: VAR tests and SURE models.
- First step: check the time series for the existence of **unit roots**.
- Second step: For causality issues, run **Granger Causality Tests** based on an unrestricted Vector Autoregression Model (VAR).
- Third step: In order to better understand the dynamics of the model, calculate **impulse response functions** (not reported here in detail).
- Final step: Reduce gently more variables in a **SURE model** (seemingly unrelated regression equations).

# Causality in the 1<sup>st</sup> period 1850-1913





# Causality in the 2<sup>nd</sup> period 1951-1999



# Which is the logic of the domestic innovation process taking place within the system?

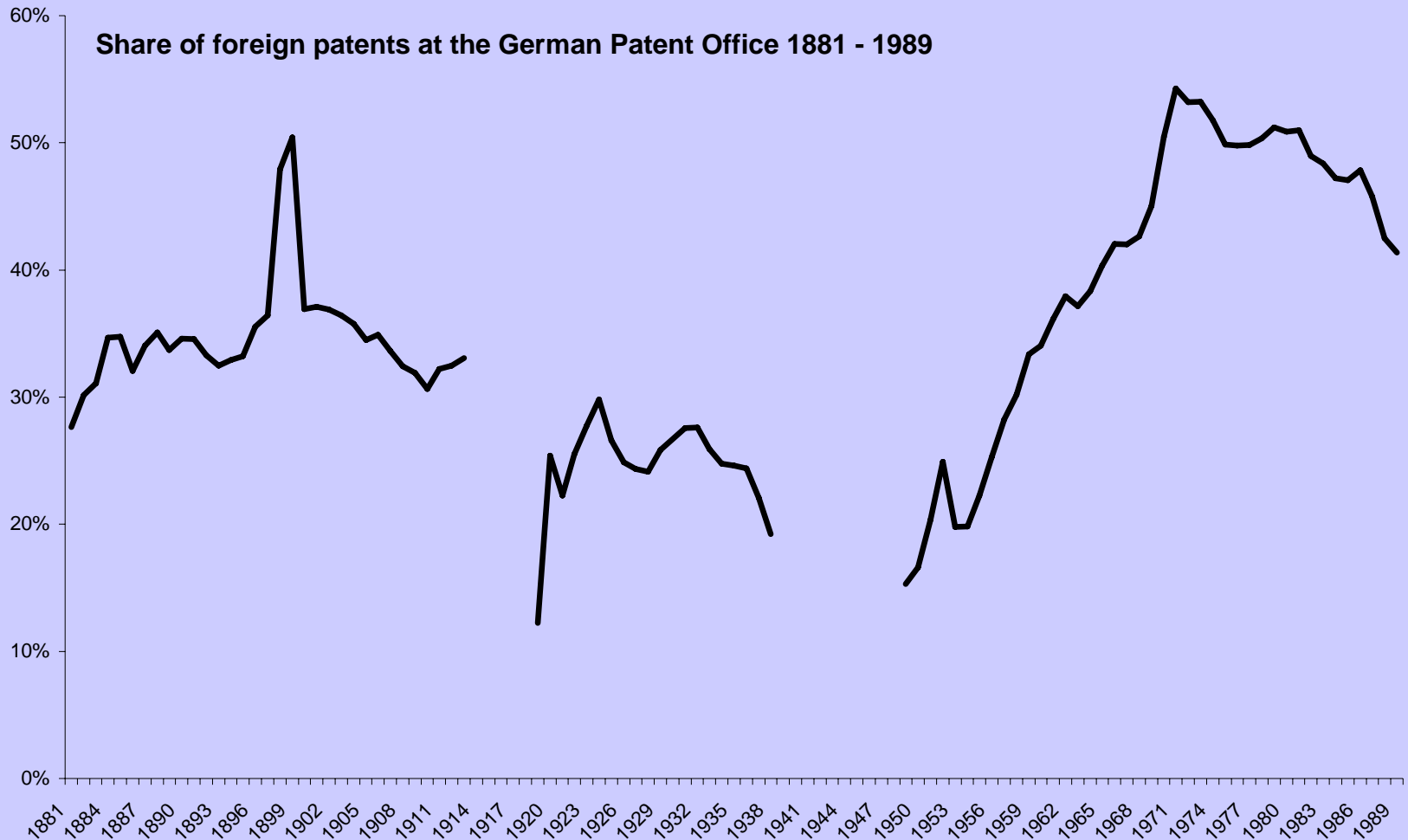
## First period

- Period of formation of a liberal, unified and large market.
- Formation of a national innovation and technological system.
- **Linear relation** from public science expenditures to technical change and economic output p.c.
- Weak influence of demand on (more) technology generation.
- Building human capital in competitive situation to technical change.

## Second period

- Post-war “economic miracle” ended by oil-price adjustment.
- **No one-way empirical specification identified.**
- While public and private expenditures via technical change drive outputs, the economy strongly explains these expenditures. No more direct influence on technology.
- Science, technology and economic growth seem to be intertwined.

# Foreign influence on national structures: since when and how much?



# Digression: Communist influence on national structures: if and how much?

- Measured by its science output, the **profile** of GDR research resembles that of the former Federal Republic.
- In spite of completely different economic conditions and a different patent law (no private property in socialism), also technology (patents) shows a **correlation** between GDR and West Germany until re-unification and thereafter.
- This **structural similarity** must be pointed out; obviously 40 years of division were not sufficient for a differentiated development of the innovation specialisation patterns in both parts of Germany: it does not look like two national innovation systems, but one. The innovation system was still based on the (common) preferences which existed prior to the division.
- Note: we deal with national, not sectorial levels.

## Conclusions ...

- The **causality** for technical change during formation and saturation of the investigated national innovation system was different: while largely a linear relation with some influence of economic demand was typical for formation, intertwined relations govern the full developed system.
- Most astonishingly, the German innovation system was **very stable** in the national aggregation although it witnessed several political system shocks in the past 150 years: The strong and the weak sides of S&T were almost the same whatever regime and territorial boundaries were around – always **one** system existed.
- This **persistence** of the innovation system points to a **resistant innovation culture** in and around Germany which may not be influenced too much by external shocks or incentives be it in monetary or institutional form.

## ...and open research questions

- Some German policy makers are afraid that globalisation and the seventh EU framework programme with its openings will **harm** the German innovation system and want to “**guard**” it. As it has proven to be able to **guard itself perfectly** in the past 150 years, will this happen again?
- The industrial research system in Germany was one of the first in the world forming and developing late in the 19<sup>th</sup> century. Other countries **followed** that pattern more or less closely. But we know too little: Did other national systems also remain largely constant over long periods?
- What about other „open“ national systems under **territorial aspects**: Anglo-Saxon tradition? Commonwealth? UK and Ireland? Soviet Union successor states? USA and Canada?

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