

# Industrial Innovation Policy: Challenges and opportunities

Babbage Forum

March 2023



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Summary Report prepared by Mike Gregory, Gordon Attenborough and Sarah Cheung Johnson on behalf of:

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Cambridge, UK | March 2023

The Babbage Forum gratefully acknowledges the support of the Gatsby Charitable Foundation

## Summary

The Babbage Forum is an international, multidisciplinary group involving senior figures from engineering, operations and economics, with common interests in Industrial Innovation policy. During 2022, its programme focussed on exploring national industrial innovation policymaking practices. The work was stimulated by the rapidly evolving industrial, technological and geopolitical landscape and the renewed interest in industrial innovation policy in many countries.

Reports were prepared for the ten member countries\*, drawing on desk research and interviews with leading policymakers in each country. A Symposium in September 2022 reviewed the reports and sought to identify generic challenges and opportunities for improvement. A number of themes of potential importance to policymakers were identified. They divide broadly into content, process and organisation:

**Content** is concerned with the factors, information and evidence that influence the shaping of industrial innovation policy. Particularly significant are:

- *International context* – to track increasingly important external influences on national policies, including rapidly evolving groupings and alliances
- *National objectives* – to ensure clarity of strategic, economic, and social objectives and learning from countries with similar objectives
- *National industrial capabilities* – to provide current, required and potential capability assessments to underpin industrial policies
- *Industrial scale-up* – to enable rapid exploitation of technological and organisational innovations addressing production and supply as well as finance

**Process** is concerned with the way in which information and evidence may be analysed and synthesised in the formation of coherent industrial innovation policies. Particularly significant are:

- *Structure and methods* – to ensure the systematic capture, analysis and synthesis of relevant expertise across science, technology, operations and history as well as economics
- *Experimentation* – to test, under controlled conditions, new approaches and improve the robustness and effectiveness of policy interventions
- *Evaluation* – to ensure the effectiveness of policies from objectives through implementation to outcomes
- *Policy learning* – to provide an historical review of policies and processes to inform future policymaking

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\* *China, France, Germany, Italy, Japan, Korea, Sweden, Singapore, UK, US.* – National papers available via the Babbage Forum web pages.

**Organisation** is concerned with the arrangements for engaging the policymaking ecosystem including government, academic institutions and think tanks. Particularly significant are:

- *Institutional ‘ecosystems’* – to ensure effective communication and capture of inputs from different parts of the policymaking landscape
- *Regional vs national priorities* – to ensure recognition and, where appropriate, reconciliation of distinctive regional vs national characteristics
- *SME engagement* – to capture the nationally significant but less visible capabilities and requirements of small vs large companies, e.g., targeted procurement

Many of these topics are familiar to experts, but the review provides an international multidisciplinary overview, together with examples of effective practices in different contexts.

## Priority themes

The observations indicate a need to improve areas of policymaking that present particular challenge and opportunity. The initial priority themes are:

- **Institutional ecosystems** – where more transparent and effective approaches to the mapping and orchestration of complex, connected ecosystems are required
- **Policymaking competencies** - where better education and training is required within government and relevant external organisations
- **Evaluation and policy learning** – where better approaches to connect objectives, outcomes and learning are required.
- **Industrial capabilities** - where more robust approaches to measurement, characterisation and analysis are needed

The Babbage Forum plans to explore these themes in greater depth and would be pleased to hear from individuals and organisations that share these interests.

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## Background

The Babbage forum was established in 2016 in response to a perceived need for broader disciplinary inputs to the development of industrial innovation policies. At that time there was a vigorous debate about the advantages and risks of industrial policy. Familiar arguments included, on the one side, that an understanding of national industrial capabilities and the need to nurture them appropriately were essential to sound management of an economy. On the other side, arguments included the risks associated with governments 'picking winners' and interfering with matters which should properly be left to the market. While this debate continues, there is recent evidence that many countries, not least the USA, which had previously avoided explicit industrial policy, now regard it as necessary.

The Babbage Forum did not seek to engage in this debate. Rather it sought to address how industrial innovation policies might best be developed once a country had decided to do so. Early discussions highlighted the need for better language for policymaking that could embrace a broader set of disciplinary inputs, including technology and operations. These fields have traditionally had limited input to policymaking except in rather narrow areas of specialism. The early discussions also identified a lack of 'process' in the formation of industrial innovation policies and the often under-appreciated role of manufacturing in some economies.

The opportunity to share practices from different countries and disciplines, often anecdotally, led to enthusiasm for a more systematic exploration of country practices. While it was recognised that national policies are contingent upon a wide range of contextual influences, nevertheless there would be areas where exchanges of policymaking practices, as distinct from specific policies, could be of value.

## Approach

Members of the Babbage Forum each undertook to prepare a report on national industrial innovation policy practices in their country, together with examples of significant policy initiatives and their implications.

A simple framework was adopted that attempted to capture the main features of country practices in a way which would facilitate later comparison.

**Content** – the factors, information and evidence that influence the shaping of industrial innovation policy.

**Processes** – the way in which information and evidence may be analysed and synthesised in the formation of coherent industrial innovation policies.

**Organisation** – the arrangements for engaging the policymaking ecosystem including government, academic institutions and think tanks.

**Cases** – examples of successful industrial innovation policy interventions to identify effective practices.

The work proceeded through four stages: participation, preparation, description, analysis. The analysis phase for each country involved reflection on the practices observed and categorisation of the apparent effectiveness of different practices and examples. At the Symposium, members heard presentations on each of the country reports. Working groups then discussed the reports.

These sessions provided an opportunity to cluster the findings from each country to reveal common challenges and practices, identifying important themes for practitioners and for future work.

## **Themes and Challenges**

The national reports and subsequent discussions highlighted a number of challenges and themes that are important to policymakers and provide the basis for more detailed attention. They divide broadly into content, process and organisation.

### **Content**

#### **International context**

International context has always been influential in the development of industrial innovation policy. An understanding of markets and the competitiveness of sectors and technologies is clearly essential. Recent international developments however include rapidly changing national capabilities and rapidly evolving realignments of relationships between major countries. The rate of these changes requires greater attention to the dynamics of international policies and relationships and a detailed understanding of the implications for global supply networks.

Over recent decades, opening borders to trade and capital flows was a priority for major industrial countries and international institutions. This has benefitted the poorest people in the world, with the percentage of those in extreme poverty falling from 42% in 1981 to 8.6% in 2018. Volumes of trade in goods and capital flows remain high but peaked about 15 years ago. Major international developments of recent years including economic and technological competition between US and China and the Russian/Ukrainian war, have accelerated changing patterns of production and trade. Earlier patterns of globalisation are being replaced by substantial re-globalisation.

Assessments of future international trends, therefore, form an increasingly important content input to industrial innovation policymaking. Perhaps the most important of these currently is the technological decoupling of major global players and the implications for smaller countries such as Singapore, Sweden and Korea. These countries may need to choose between different sets of technologies, standards and partners. The impacts on supply chain configuration and investment are already apparent and judgements about their likely evolution will be critical. Reshoring and 'friendshoring' seem likely to increase. While the US was previously committed to a more integrated world economy, geopolitical concerns are pushing it toward a more national focus and a very active industrial policy. Many countries are now reviewing their industrial policies to take account of these changing circumstances. In the UK for example a significant government reshuffle in part reflects the changing international context.

## Clarity of objectives

Objectives are the first point of focus for industrial innovation policymaking. In modern democracies, high-level objectives are typically set out in election manifestos. Within this broad framework however, a great deal of objective-setting goes on at the level of politicians and officials and involves a wide variety of often obscure trade-offs in the allocation of resources. The clarity and precision of objectives are fundamental to the creation of effective policies. Who is, and who should be, responsible for setting objectives can be problematic, particularly in the context of science, technology and innovation. Increasingly consideration needs to be given to broader societal industrial strategy objectives.

Objectives may be clear and quantitative, for instance in the case of greenhouse gas emissions or energy use, or they may be more qualitative, for example, improvements in social welfare. Clearly better framing of objectives is more likely to lead to improved policies, but the mechanisms for objective setting are often obscure and approaches vary internationally. Despite this variation, there are many similar themes including energy, environment and competitiveness which follow high-level objectives including economic growth, greater productivity, resilience and national security.

China has clear, structured processes through established State bodies which develop, disseminate and monitor objectives centrally. Germany has an advisory group on research and innovation which submits a report to government once a year identifying needs for policy intervention. In the UK, objective-setting is less procedural, which has the benefit of flexibility but may lack precision, such as the policy of 'levelling up.' The US lacks an overall innovation objective-setting strategy; instead, particular efforts tied to sectors, such as energy or semiconductors, develop based on policy needs that emerge.

## National industrial capabilities

National industrial capabilities are determined by the capabilities of enterprises within the nation, together with the scientific and technological infrastructure and the regulatory environment. Once policy objectives have been established, effective policymaking depends upon clear understanding of current capabilities.

Some capabilities are readily determined, such as the production of steel or automobiles. Others are much less visible and it may be that a unique national capability is held in small businesses which are not typically part of the routine consultation processes through which larger businesses are engaged. Many countries depend upon detailed sectoral industrial analyses but these can be influenced, if not distorted, by the demands of well-established players. Again, reliable information about current activities is vital but may not always map on to the needs of policymakers seeking to understand and quantify current and potential future opportunities and indeed areas which should not be prioritised. Capabilities data in standard formats is rarely available and protocols for defining and assessing capability are limited. This is an area of need for many countries.

In France national industrial capabilities are a key input to policymaking. The State is active in the ownership of key industries and the provision of national research and development capability through its CNRS. In China, all strategic industries have major State-owned businesses and again support a complex publicly funded research and development infrastructure with close links to industry. In the USA, government's emphasis since the end of World War II has been on research, not industrial capacity, which has been left to business, except in its defence sector. It has strong university research

and large national laboratories charged with developing national scientific efforts, although later stage innovation in defence, space and, to some extent health sectors, receive government support. Recent major legislation, however, has moved the US more toward industrial policies. A recent development has been the emergence of manufacturing innovation Institutes in the UK, US and China, aimed at bridging the gaps between science, technology and application.

## **Industrial scale-up**

Scale-up is important at both firm and national levels. At the firm level, it offers the opportunity to capture value from an innovation before competitors can catch up. This can allow the innovator to capture greater margins than would be possible once the product has matured. At the national level it offers the opportunity for countries to capture benefits from public investments in R&D and may enhance national competitive positions.

Firms address scale-up through rapidly evolving business models, typically beginning with small volume, high value products requiring investment to develop and prove products, identify and develop markets and create supply and distribution networks. Once market demand and volume are established then costs and prices can fall, while maintaining or improving margins but further investment in production capability will be required. Financial scale-up is often identified as the major barrier to growth. Typically, public funds are deployed in the early stages of scientific development and private companies are expected to pick up and develop promising technologies. Much attention has been focused on the need for investment in these, often risky, development stages but production scale-up may be equally challenging.

Scale-up also has important technological dimensions. For example, a production process well suited to low volumes may be inadequate for high-volume production, potentially requiring a major product and process redesign.

Some countries use Technology Readiness Levels (TRLs) and Manufacturing Readiness Levels (MRLs) to track and manage scale-up activities. The US has long applied these in its defence and space sectors.

Historically Japan and Korea have demonstrated outstanding capability in production scale-up with sophisticated factory-based expertise and meticulous planning and execution. A less well-known example of US support to scale-up, in this case to promote electric vehicles to meet climate goals, was a \$428m federal loan to Tesla at a critical stage of its growth, as well as funding from offsets from other car makers. In France, there is strong political interest and support for start-up companies with the leading 120 given direct access to ministers. The president is also active in promoting the country's technical strengths internationally.

## **Process**

### **Structure and methods**

Process is concerned with the steps or stages which are necessary to move from a policy objective to a clear policy statement and delivery plan capable of being understood and deployed effectively. Such processes for industrial innovation policymaking demand a wide range of expertise across science, technology, operations and history as well as economics. Clear, well-defined processes can help ensure that all relevant issues and information are considered systematically. They also allow for policies to be



revisited with a clear record of how they were determined. There are risks, however, that if policymaking becomes too formulaic, then emerging trends may be missed and innovations in policymaking itself inhibited.

Established and documented processes are used in many areas of government but are less common in the development of industrial policy. In part this is due to differences of opinion about the nature of, or indeed necessity for, industrial policies and in part due to the multiple objectives and contexts that such policies are expected to address. There are however many sub-processes within a broad policymaking activity which can be identified and shared between different national contexts. Policymaking capability and access to appropriate experience and expertise are a universal challenge. Whether in-house or through the sourcing of external agents, the multidisciplinary skills required are rare.

There are considerable variations in the approaches adopted in different countries. China and Sweden have clear and well-structured processes. In the USA policymaking is highly distributed across many agencies with policy proposals that help meet agency missions from different sources competing for support. New US industrial policy programs still tend to be implemented through particular mission agencies, with cross-agency collaboration difficult. In the UK there are few established processes for industrial innovation policy formulation which tend to reflect the preferences of the groups, or individuals in power!

## **Experimentation**

Experimentation is concerned with assessing the effectiveness of policies at a small scale in controlled conditions before significant deployment. Experimentation can offer early insights into new approaches and improve the robustness and effectiveness of policy interventions. It is, however, much more challenging than scientific experimentation which can typically be decoupled from its environment. Nevertheless, experiments can provide vital input to policymaking – particularly important where the consequences are far-reaching. Many nations recognise the potential benefits of such experimentation but there appear to be few widely recognised ‘protocols’ for such initiatives.

There appears to be relatively little sharing internationally, of effective practices in experimentation. Arguably, this is because of cultural differences across countries but also between ‘officials’ and ‘managers’. Managers are typically more accustomed to dealing with risk and probability whereas officials are typically more risk averse. This is appropriate for orderly and secure public administration but can militate against innovation.

In Germany there is considerable enthusiasm for experimentation and the Lander structure provides opportunities for policies to be ‘tested’ without committing to a federal programme. Similarly, in the US individual States can provide a test bed for new policies providing evidence to the federal government. The encouragement of electric vehicles and the provision of necessary infrastructure in California is an example which has been closely observed by other States. In Singapore the ‘sandbox’ concept allows for experimentation in carefully controlled circumstances so that the potential impact can be explored.

## **Evaluation**

Evaluation is concerned with assessing the effectiveness of policies before, during and after implementation. It is widely recognised as important and is pursued by all countries to some degree. Most commonly, this is driven by accounting and finance departments keen to ensure that funds have been disbursed as intended. More comprehensive evaluation is hampered by the difficulty of measuring subjective outcomes such as societal benefits.

Good evaluation depends on the clarity and precision with which initial objectives and targets are set. Ideally evaluation should be undertaken at every stage of the policy development and implementation process. Initially the feasibility of a proposed policy should be assessed and then followed through implementation to enable mid-course corrections including, where necessary, closing ineffective programmes. Care is clearly needed to ensure that evaluations are sufficiently independent as Government departments being responsible for their own evaluation may lead to conflicts of interest. In some countries, evaluation is routinely outsourced to independent commercial companies. While this has the benefit of impartiality, it may mean that expertise is lost, so some countries provide independent internal evaluation capability within government.

In practice evaluation is most commonly undertaken shortly after the conclusion of a policy implementation. This risks missing the potential long-term outcomes, though such outcomes become difficult to assess the closer to market they are. The issue of ‘not in my term of office’ reflects a common political pressure to avoid policies that will not come to fruition and be evaluated within the incumbent’s term of office and for which successors may take the credit.

Sweden and France have well developed evaluation regimes. In Sweden the model of agencies and project management organisations independent of government, allows for independence and continuity. In the UK the Green and Magenta books provide high level guidelines on policy evaluation and have recently been revised to encourage the assessment of societal as well as economic outcomes. In the US, only a few agencies undertake systematic technology program evaluations, although its National Academies of Sciences in some cases plays this evaluation role.

### **Policy learning**

Policy learning is concerned with the systematic capture of lessons from policy development and implementation and the use of those lessons to inform future policymaking. The potential benefits of policy learning are widely recognised but there are few examples of effective practices.

Few countries appear to be systematic in the collection and analysis of learning from past policies and policymaking. A more ‘historically’ informed approach to policymaking could offer benefits in terms of learning from past success but also avoiding pitfalls. The challenges to effective policy learning include the political dynamics of policymaking, which favour early action and results, and the concern that changing contexts may invalidate historical lessons.

Frequent movement of politicians and civil servants between roles leads to organisational volatility. Such lack of continuity results in a lack of ‘history keepers’ or archivists and the loss of government knowledge of previous policy development and implementation, failures and successes.

Nevertheless, some countries are able to demonstrate policy learning. Singapore stands out in this respect. It has, however, the great advantage of essentially the same government, indeed some of the

same individuals, in position for decades. Sweden also has strong mechanisms for effective policy learning through independent agencies as well as within government. There are also opportunities for learning from other countries, though again with the need to understand contexts and their influence. This process is largely missing at the presidential and agency levels in the US, although, again, its National Academy of Sciences has undertaken it in a number of cases.

## **Organisations**

### **Institutional ecosystems**

Institutional ecosystems are concerned with the nature of, and connections between, organisations involved in the industrial innovation policy process. This network of organisations can perhaps best be described as an ‘ecosystem’ including government departments (usually several), universities, specialised research institutes and think-tanks. The term ‘ecosystem’ is appropriate because the various organisations within it do not, typically, have formal links. Rather, taken together, they hold the knowledge, expertise and experience necessary for robust policymaking.

The organisations making up the ‘ecosystem’ have a variety of roles. Industry associations may have the best access to industrial companies within specific sectors. National academies may hold leading-edge professional expertise. Think-tanks typically contribute policy ideas and analyses – some reflecting the interests of their sponsors. Universities can offer insights into emerging science and technology while national laboratories may hold and develop strategic technologies. Government departments typically have access to economic and social data and are responsible for synthesising policies, managing the policy process and managing deployment and implementation. While such rich ecosystems present challenges of co-ordination, they provide important checks and balances before, during and after the policymaking process.

China and Singapore have very clear structures, routines and organisations involved in policymaking. Others, such as Korea and Germany, have much more diverse ‘ecosystems’. In the case of Korea, this diversity is focused by the setting of very clear high-level objectives at the national level. In the US and UK multiple organisations are connected to the policymaking process which tends to be more organic and include political direction interacting with consultation and expert review.

### **Regional versus national**

Industrial innovation policies can be made at national and regional levels. This reflects the differing contexts and capabilities in different regions within the same country. The balance between national and regional policymaking varies considerably, reflecting the strengths and weaknesses of national and regional bodies. There are also clear conflicts of interest. What is good for one region may be bad for another and national policies may enhance or stifle local initiative.

There is a wide range of organisational models which seek to strike the balance between national and regional interests. Frequently, in democracies, the regional interests of key political figures may be very important to central government. Regions are also much better placed to ensure the effective implementation of policies.

Countries with strong central direction of policymaking include China, France, Sweden and Japan, though in each case there is considerable freedom at the regional levels to interpret and deploy according to local requirements.

Countries with stronger regional arrangements include Italy, Germany and the USA where states retain considerable freedom and have their own resources, which typically are used to support existing industry and economic development rather than research. Italy has particularly strong regional arrangements with Emilia Romagna, for example, pursuing its own distinctive industrial policies over many decades.

Some nations do not fit into either category. Singapore has a uniquely centralised system, a function perhaps of its size and long-term continuity of government. Sweden adopts a unique arrangement involving small central ministries providing oversight of strong delivery agencies.

### **SME engagement**

SMEs represent a very important part of the industrial landscape in many countries. They vary dramatically. At one end of the spectrum are small, local businesses undertaking relatively straightforward activities serving local communities with little prospect of growth. At the other end are specialised businesses in high-tech fields with globally leading positions. Famously Germany's Mittelstand companies represent the latter type of company while China is actively seeking out 'hidden champions'. Engagement with these businesses requires different approaches from engagement with large companies.

It is widely recognised that SMEs play an essential role in industrial success both as suppliers to larger businesses but also, in the case of start-ups, as the next generation of major corporations. SME managements are, however, notoriously difficult to access as they are often nervous about engaging with government, not least because of the potential administrative burdens. Addressing the needs and potential of SMEs is further complicated by the wide diversity of such businesses. Ideally, the focus would be on high-growth companies or those which, despite their relatively small scale, hold a distinct, globally competitive technology or product.

Germany's 'Mittelstand' companies, many of which enjoy global positions in their industries, tend to be family owned and managed. A government department is well established, catering specifically for the needs of such businesses. In the UK the relatively new Catapult Centres are required to reach out to SMEs to support technological development, while government-funded regional growth hubs seek to provide business support to SMEs. In the US, manufacturing SMEs, which supply nearly half of US manufacturing output, tend to lag in productivity and are not well-connected to existing programs. While the US has strong entrepreneurial startups in software and biotech, it has far fewer in "hardtech" and manufacturing.

### **Conclusions**

Many countries are now reviewing their industrial innovation policies in light of rapidly evolving scientific, technological, societal and geopolitical landscapes. In some countries, such as the USA, this represents a marked shift in approach involving greater central Government engagement with

industry. In others, such as China, it is a continuation of well-established approaches but in a changing context.

Reports were prepared by Babbage Forum members for ten member countries\*, drawing on desk research and interviews with leading policymakers in each country. A Symposium in September 2022 reviewed the reports and sought to identify 'generic' challenges and opportunities for improvement.

While the context and approaches of different countries vary significantly, many face similar challenges and common themes have emerged together with some examples of significant policies and practices. Essential features of industrial innovation policymaking systems include:

The **content** of industrial innovation policies should address: the changing international context, national objectives, industrial capabilities and scale-up.

The **processes** for industrial policymaking should include: structure and methods, experimentation, evaluation and policy learning.

The **organisation** for industrial innovation policymaking should consider: institutional configuration, regional vs national focus and SME engagement.

Priority areas, where deeper understanding and better sharing of effective practices are needed include:

**Institutional ecosystems** – where more transparent and effective approaches to the mapping and orchestration of complex, connected ecosystems are required

**Policymaking competencies** - where better education and training is required within government and relevant external organisations

**Evaluation and Policy learning** – where better approaches to connect objectives, outcomes and learning are required.

**Industrial capabilities** - where more robust approaches to measurement, characterisation and analysis are needed

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\* *China, France, Germany, Italy, Japan, Korea, Sweden, Singapore, UK, US. – National papers available via the Babbage Forum web pages*

## About us

Cambridge Industrial Innovation Policy (CIIP) is a global, not-for-profit policy group based at the Institute for Manufacturing (IfM), University of Cambridge. CIIP works with governments and global organisations to promote industrial competitiveness and technological innovation. We offer new evidence, insights and tools based on the latest academic thinking and international best practices.

This report was delivered through the Babbage Forum. 17 Charles Babbage Road, Cambridge, CB3 0FS, United Kingdom [cijp.group.cam.ac.uk](http://cijp.group.cam.ac.uk)

