COMPETITION IN INTERNATIONAL AUTOMOTIVE AND AEROSPACE TECHNOLOGIES

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Introduction

This chapter is a brief review of technology policy in the automotive and aerospace industries, seeking to explain what policies governments use in order to influence technology development, and what impact these policies may have. It analyses the issues around aerospace and automotive industry technology policies in three steps: first, the key features that characterise the automotive and aerospace industries; second, the range of policy instruments governments use in order to foster R&D and technology development in these industries; and third, assessing the impacts of these policies, not only on the development of particular technologies, but more broadly on the structures, competitiveness and geographies of both industries.

The nature of the aerospace and automotive industries

The automotive and aerospace industries are both assembly industries, manufacturing thousands, even millions, of parts and assembling them into technically complex vehicles. As such they have broad structural characteristics, and even participant companies, in common. Each consists of: primary manufacturers (primes) broadly capable of designing, developing and assembling whole vehicles, and integrating the technical systems they embody; a range of specialist suppliers of components; and specialist research and training facilities. The automotive industry is fundamentally a consumer goods industry. By contrast, the aerospace industry is overwhelmingly a producer goods industry, manufacturing vehicles to be used as producer goods by airlines, and a manufacturer of military aircraft for governments.

Both industries are mature with oligopolistic characteristics, having been subject to industrial concentration over recent decades. The primary manufacturers in both sectors are globally recognisable names (e.g. Boeing, Lockheed Martin, EADS in aerospace; Ford, Toyota, Mercedes, Fiat-Chrysler in automotive). In the automotive industry the demands for greater economies of scale in design and manufacturing have driven the process of industrial consolidation since
By 2005 it was estimated that a globally competitive automotive manufacturer, producing a full range of vehicles, would need an annual production of 3 million vehicles. However, consolidation has not resolved the industry’s persistent problem of low profitability. Its most established markets (in Europe, the US and Japan) are saturated, but high capital intensity dictates high production volumes, despite flagging demand and low returns on capital (Nieuwenhuis et al. 2006). In aerospace, consolidation has been driven more strongly by the costs and complexity of R&D, although recent and anticipated cuts in military spending are adding further pressures.

Two key differences in the respective patterns of concentration are ownership and geography. In aerospace, strategic considerations make national ownership and control critical for governments (e.g. in late 2012, merger talks between EADS and BAE Systems appear to have foundered because of governmental concerns about loss of national control). Similarly, the US Government seems reluctant to allow much further concentration of ownership among its primary suppliers (Financial Times 2012a). Policy focuses on the retention of national capability. By contrast, in automotive, weak companies such as Chrysler can be passed from one overseas partner to another without a government veto. In the automotive industry production is dispersed. The major automotive manufacturers, while tending to keep core engineering and design functions close to their headquarters, have major production facilities outside their home markets, close to the customer. They also conduct some research and design activities abroad, in markets that have particular customer requirements or technical expertise to draw on. Increasingly, they conduct these activities in both the ‘continentalised’ European and North American markets, and in emerging markets such as China and Brazil (Sturgeon et al. 2008). In aerospace key R&D functions are retained at home, as is commercially and security sensitive assembly work.

Supporting the primes in both sectors are complex networks of subcontractors that are fundamental to their competitiveness. For example, car makers typically only manufacture 25 per cent of the value of the vehicles they build (Maxton and Wormald 2004). Subcontractors provide a vast range of products and services for both industries from the technologically unsophisticated to the highly complex. These suppliers are organised into tiers, with the first tier suppliers often being major, high technology businesses (e.g. Bosch, GKN). As one moves down the supply chain, there are more regionally based and low technology suppliers. Both cars and aircraft have become increasingly dependent upon electronics and computing to run and manage vehicles. This has drawn major specialist suppliers into both sectors, and has made the primes increasingly dependent upon them to provide subsystems critical to product competitiveness.

Both industries present very high barriers to potential new entrants. The dominant firms benefit from formidable economies of scale. As Sperling and Gordon (2009: 213) comment, ‘One can’t launch a car company from a backyard garage like one can a software or internet company.’ Such barriers are arguably more severe in aerospace, because of the high R&D costs associated with the development of a new aircraft, and the long payback period (typically fifteen years) to recover that investment. Overcoming these barriers requires a growing home market, strategic vision, persistence and, usually, extensive government support. Among developing nations, currently these conditions are, arguably, best met in China, which has long-term growth potential and has pursued clear objectives about the particular market segments to be developed and the technologies needed in both sectors (Maxton and Wormald 2004; Cliff et al. 2011). India, while having many similar advantages, has pursued a less focused national strategy (e.g. Mani 2010).

For both industries R&D is critical, being the key to product differentiation and so to competitiveness. It is hugely expensive, complex and frequently path-dependent. ‘The creation
and introduction of a new [automotive] vehicle is a mammoth project, involving very big commitments of time and money – it is quite capable of breaking a company if it goes wrong’ (Maxton and Wormald 2004: 141). Similarly Newhouse (1982) referred to the aerospace industry as ‘The Sporty Game’, because developing a new aircraft involved ‘betting the company’. Both sectors share some key research priorities, in particular reducing vehicle weight, increasing fuel economy and reducing the lifetime cost of vehicle ownership (Price Waterhouse Coopers 2012a). These involve, for example, the development of new, lighter, materials, electronic engine management systems, the replacement of hydraulic with electrical controls, and the development of new, non-hydrocarbon-based fuels (Price Waterhouse Coopers 2011). Currently, Boeing and Airbus are both developing new variants of their short-haul jets (the 737 MAX and the A320 NEO) using new more efficient engines, while the automotive industry is developing both electric cars (e.g. the Nissan Leaf) and hybrid fuel cars (e.g. the Chevrolet Volt) (Economist 2013).

The aerospace industry has the longest project lead times of any manufacturing industry, typically about ten years (as well as the most complex supply chains) (Price Waterhouse Coopers 2010). Successful aircraft also have exceptionally long product life cycles. The Boeing 747 has been manufactured for forty years. The industry is still riding the ‘innovatory wave’ generated by the advent of the jet engine, and its associated aerodynamic developments (e.g. swept wings), that entered service in the 1940s. However, the industry has also received major innovatory impetus from the advances in IT and new materials technologies since the 1970s. The effect of high project start-up costs and long payback periods is that aerospace companies are unlikely, even unable, to proceed with major new product developments without public subsidy. Although they have become much more complex, cars remain technologically simpler than aircraft, but are mass produced in volumes unimaginable in aerospace. Greater product simplicity results in: much shorter times to market; shorter product life cycles; a wider range of products in manufacture; and, an industry where production technologies have a greater saliency. R&D activity in automotive has been generally more a single company-based process than in aerospace. This is essentially because production volumes are incomparably greater in relation to R&D costs, and projects are technologically simpler. Given the importance of R&D to both industries, neither is well suited to short-termism in management decision making, which can lead to a neglect of technological innovation (because payback is uncertain and may be years away) and a loss of long-term competitiveness (e.g. Boeing between launches of the 777 and 787).

Policy instruments

The technologies of both industries have been greatly influenced by government policies. However, the policy instruments that governments have used to influence them, and the extent of that influence, have varied. It is not possible to understand the aerospace industry, even civil aerospace, without understanding its symbiotic relationship with government. In the automotive industry government influence has been less than all pervasive. This section will now explore the policy instruments used by governments to influence technological development in both sectors as follows: influence over the ownership and structure; subsidies; government research facilities and universities; aircraft purchasing; and regulation.

Both the automotive and aerospace industries enjoy high levels of political saliency. In countries where they are large, or are a focus for economic development, governments recognise them as having key roles to play in economic policy, industrial policy, technology policy, employment policy and regional policy. As Maxton and Wormald (2004: 95) commented, ‘Ownership and control in the automotive sector are very important political, economic and social issues.’
Aerospace enjoys an even greater saliency because of its strategic importance. In addition, its very long time horizons, together with the incremental, path-dependent, nature of much technical improvement, place a high priority on organisational stability, keeping research, design and production teams and facilities together. This necessitates not only a steady stream of work, but also a stable organisational context. These organisational considerations apply in the automotive sector, but the shorter time horizons, greater autonomy of automotive companies, and the lack of a defence imperative, make them less salient for public policy, at least among nations with an established car industry. Few developing economies are likely to have the capability to develop an internationally competitive and substantially autonomous industry in either sector. For developing nations attempting to enter either sector, the ways in which they structure infant aerospace or automotive industries will critically impact upon their capacity to develop or acquire the necessary technologies.

Between 1945 and the 1960s, a ‘national champions’ policy was common in Western Europe for both sectors. The implication was that the national champion companies would dominate their national markets while attempting to export. However, from the 1960s in automotive, mass production and the internationalisation of markets forced concentration in the industry. At the same time in aerospace, rising costs (especially R&D), and increasing technological complexity, rendered national champions incapable of developing major new aircraft independently. Public ownership was frequently used as a means of protecting national champions that had become uncompetitive (e.g. Rolls Royce), and nationalisation was often justified in terms of protecting national technological competitiveness. Even though European governments have not been able to maintain autonomous aerospace companies, some retain an element of public ownership (e.g. Finmeccanica in Italy). State ownership impacted directly on the governance of Airbus, and later of EADS, reflecting a reluctance by partner governments to cede national control of their aerospace champions. Where governments have not taken ownership in aerospace companies, as in the US, they have still exercised considerable influence over the industry’s structure. The US Government has at times encouraged mergers (e.g. Boeing’s takeover of McDonnell Douglas) and currently appears to be discouraging them between its major primes (Financial Times 2012a).

Because it lacks the defence significance of aerospace, and has been less dependent upon government funding, a more liberal policy regime has generally been applied by governments to ownership and control in automotive. This has not precluded taking automotive companies into full or partial state ownership (e.g. the French Government currently owns 15 per cent of Renault). Nevertheless, in general it has been easier for major automotive companies to merge with and take over foreign competitors (e.g. Land Rover has been owned by BMW, Ford and now Tata). In addition it has been easier to set up not only production plants but also R&D facilities abroad. Both of these strategies have led to an international diffusion and sharing of automotive technologies.

For developing economies attempting to enter either sector, ownership and control are highly significant in enabling them to acquire or develop the necessary technologies. The Chinese Government’s Tenth Five Year Plan specifically set out the pathway for automotive industry development to 2006, including: the sectors of the market to be pursued; the role of joint ventures; and, the pace and directions of technology development (Maxton and Wormald 2004). Governments in other developing countries have used similar methods, such as state ownership (e.g. Hindustan Aeronautics), partial state ownership of joint ventures (e.g. Maruti Motors in India, Proton in Malaysia), and restrictions on the foreign ownership of joint ventures (currently 26 per cent in Indian aerospace) (Mani 2010). What appears to distinguish the Chinese approach

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is the coherence and persistence with which its development strategy in the automotive and aerospace industries has been pursued. For smaller developing economies, attempting to enter these huge, well established industries is, if anything, even more daunting. They need a ‘Chinese’ consistency of purpose, but also a keen perception of the niche opportunities in which they are likely to be competitive (e.g. maintenance, repair and overhaul for ST Engineering in Singapore).

Both industries receive public subsidies to support their technological development, but to varying extents. The significance of public R&D subsidies in aerospace cannot be overestimated. In military aerospace national governments are the primary customers for their industry’s aircraft. In civil aviation project start-up periods are long, R&D costs huge, and payback periods long, hence private capital markets have failed consistently to invest sufficiently in such very long-term and relatively high risk projects, so necessitating public subsidy. The patterns of aerospace subsidy between the US and Europe vary markedly. In Europe, subsidies have tended to be direct financial aid in the form of cheap loans to pay part of aircraft development costs. Given the oligopoly and market dominance of American civil aircraft manufacturers in the 1960s, Airbus could not have achieved a competitive and sustainable market position without it. In addition, the EU subsidises joint pre-competitive research in aerospace, such as the joint EU–aerospace industry Clean Sky Initiative which will be worth 1.6 billion euros across the aerospace supply chain. In the US, financial support for civil aerospace R&D has tended to be more indirect, not least via the funding of military and space R&D. Clearly, knowledge both of design and manufacturing can pass between complementary projects. As the Arnold and Porter Report (1991) commented, there is ‘massive, systematic support to the US commercial aircraft industry pursuant to a long-standing US policy of striving to maintain US superiority in all areas of aeronautics technology’ (quoted by Lawrence and Thornton 2005: 116). More recently, however, Boeing has additionally become heavily reliant on direct public subsidies to support the 787 project, from the state governments of Kansas and Washington and from the governments of Japan and Italy. This jockeying for market share and technological advancement, using different forms of subsidy, has led to a series of international trade disputes between the US and Europe over the past two decades. Clearly, facing such heavy subsidies paid to the market leaders, new entrants are themselves inevitably heavily dependent upon such subsidies in order to break into the industry. For example, the Indian Government will pay 80 per cent of R&D costs on its defence contracts, plus a tax benefit of 150 per cent of the contractor’s internal R&D costs (Confederation of Indian Industry and Price Waterhouse Coopers 2009).

The automotive industry receives significant public subsidies, but there are two key differences to the aerospace sector: first, subsidies are smaller and less all pervasive upon the industry’s priorities; and second, their priority is largely towards the support of manufacturing facilities. For about two decades public R&D subsidies to automotive, especially in its three dominant markets, have prioritised new technologies to reduce dependence on petroleum. The motivations for this have been: environmental, economic (to equip domestic manufacturers to compete more effectively with cars that are cheaper to run) and strategic (to reduce dependency on oil imports).

These subsidies cover a wide range of measures necessary to introduce the new technologies (e.g. for new manufacturing technologies, for developing less polluting fuels). They are also large (e.g. the US electric car specialist Tesla received a $465 million loan from the Department of Energy, and its Model S is subsidised for consumers by a $7,500 federal tax credit (Financial Times 2013a); in Japan, lithium-ion battery manufacturer GS Yuasa has received a loan of $3.5 billion from the Ministry of Economy, Trade and Industry, mainly to support the production of these batteries for hybrid vehicles (New York Times 2013)). Following the financial crash of 2008, the widespread use of ‘scrappage’ schemes (subsidising consumers to buy new vehicles,
while trading in older ones for scrap) were often explicitly linked to the replacement of the older vehicle by one that was more fuel efficient, thereby boosting demand for vehicles embodying greener technologies.

Of course, countries in the early stages of developing an internationally competitive automotive industry need a more broadly based strategy to acquire the necessary technologies, as the Japanese industry ministry MITI did in its 1955 five-year plan to develop the automotive industry that included substantial access to cheap capital for new technology development. Currently the Chinese Government is working to make up the shortfall in indigenous automotive R&D; however, the sums being spent are still small (e.g. $100 million on fuel cell, electric car and hybrid vehicle technologies; Sperling and Gordon 2009). Currently their policy focus is primarily on the acquisition of existing technologies via joint ventures.

Apart from research subsidies to companies, governments directly conduct aerospace and automotive research and fund it in universities. Again there is, however, some difference in the scale and intensity of such activities. The military significance of aerospace, and the priority for technological and engineering developments, led governments to create their own industry-based research institutions in the early decades of the last century (e.g. the US Langley Research Center), rather than rely solely on companies and universities. Government research laboratories and testing facilities have been critical to technological advance in aerospace (e.g. the Office National d’Etudes et de Recherches Aerospatiale in France, India’s National Aerospace Laboratories at Bangalore). Government laboratories both conduct projects of direct value to particular companies (e.g. the Langley Research Center works very closely with Boeing; Newhouse 2007), and pursue a wide range of more generally useful research projects, from ‘blue skies’ research to technological developments of relevance to the next generation of products. The automotive industry also frequently benefits from the work of government research laboratories, but such laboratories are more likely to be focused on related scientific disciplines, rather than the specific needs of the automotive sector (e.g. in the US the National Laboratories at Argonne and Oak Ridge, both controlled by the Department of Energy, provide research support for various industries, including automotive, in fields such as future engine technologies and alternative fuels). There are generally fewer, more bespoke, government laboratories specifically serving the automotive industry, such as the China Automotive Technology and Research Center at Tianjin.

Universities have tended to play a subordinate, but still appreciable, role in both aerospace and automotive research, as well as being key sources of highly skilled labour. Their involvement tends to be greatest towards the ‘blue skies’ end of the research spectrum, where their expertise is greater, and which does not require a large industrial engineering infrastructure. So university links to the industries can be very close and multifaceted (e.g. between the University of Washington and Boeing, between Cranfield University and Jaguar). Such research can be critical in developing leading-edge technologies, such as in Alcoa’s collaboration with Stanford University to develop airframe fasteners that function additionally as sensors to reduce the need for manual monitoring of aircraft in service (Price Waterhouse Coopers 2011). Universities also play a key role in supplying highly skilled, technological labour, but again governments have specifically prioritised the supply of skilled labour in aerospace, by creating and funding specialist educational and research institutions (Sup’Aero in France, the Beijing University of Aeronautics and Astronautics), as well as supporting engineering education more broadly through their general funding of higher education. A large supply of highly skilled engineering labour is seen as a key area of potential competitive advantage for emerging economies such as India and China. This is particularly significant in aerospace, where the leading manufacturers are suffering skilled labour shortages (Price Waterhouse Coopers 2011).
Governments’ role as a purchaser of (mainly military) aircraft, and their ability to persuade airlines and foreign governments to buy particular aircraft, is a critical feature of the aerospace industry that has no parallel in automotive. Military contracts have generally been the lifeblood of the aerospace industry, because airlines have tended to buy aircraft in smaller numbers. Military priorities have greatly affected the development of the industry as a whole. In particular, technologies developed for military purposes have been used on many civil projects (e.g. technology for the B2 Stealth Bomber has been used on the Boeing 787). This position has gradually been changing since the end of the Cold War, both because of reductions in military orders, and because of the rapid growth of air transport. Since the 2008 economic downturn, cuts in military budgets in Europe, and the prospect of severe cuts in the US, have reinforced these trends, so that increasingly, major aircraft manufacturers are coming to depend more on commercial sales (Price Waterhouse Coopers 2012b).

In the past, when many airlines were publicly owned, governments often required them to buy planes made by their domestic aircraft industry. Even now when there are fewer state-owned airlines, governments continue to exercise significant influence on commercial aircraft purchases (e.g. the US Government has been very persuasive in support of Boeing’s dominance of Japanese airline fleets). However, this influence is most obviously present in China, where airliner purchases remain an arm of broader public policy. For example, one or more of Chinese state airlines will be obliged to buy the new, Chinese single-aisle COMAC C919 airliner (Cliff et al. 2011). Worldwide, now that there are fewer state-owned airlines, and airlines are generally more economically deregulated, government influence over their purchases is less direct, and arguably less significant, but it remains important.

It is also important to recognise that aircraft purchasers can be well placed to use their purchases to foster industrial and technological policy objectives. Purchasers use aircraft purchases to negotiate ‘offsets’ (where the aircraft manufacturer agrees to set up manufacturing facilities in the purchasing country). Such ‘offsets’ can form the basis for aerospace clusters. China is perhaps the best example for civil but not military aircraft, because its domestic market is potentially so large. Cliff et al. (2011: 42) have commented: ‘Certainly, Chinese aviation industry leaders have made no secret of their desire to trade market access for technology, and joint ventures are their vehicle for gaining access to advanced Western technologies.’ For example, Airbus has built its first non-European assembly line in Tianjin. Similarly, in India defence contracts specify that 30 per cent of the value of the contract must be spent with Indian companies or joint ventures. In automotive, FDI has often also been a price for market access (e.g. Japanese transplants in the US and Europe; European transplants in China) though here, of course, the government is not itself the key purchaser of vehicles – its citizens are (Sturgeon et al. 2008).

Governmental regulation of the aerospace and automotive industries is significant and impacts on technology development in both sectors. It has primarily focused on international trade, on product safety, on environmental pollution, and on the protection of intellectual property. In aerospace, international trade regulations are mostly a civil matter, since military exports are governed by national regulations protecting security interests. Jockeying for market share and technological advancement, using different forms of subsidy, has led to a series of recurring disputes between the US and Europe for over two decades. A bilateral agreement about subsidy levels was reached by the EU and US in 1992, but the US (at Boeing’s behest) withdrew its agreement in 2004, leading to parallel claims disputes about Boeing and Airbus subsidies being taken to the WTO. In 2012 the WTO found that both parties were guilty of illegal subsidies ($18 billion to Airbus and $4 billion to Boeing). The dispute appears to have moved on to issues of compliance, but may eventually be settled bilaterally, avoiding mutual trade sanctions (Financial Times 2012b).
In the automotive industry governments have regularly protected their manufacturers, but the primary focus in international trade has been on tariff barriers, and sometimes quotas, to cut imports, rather than on subsidies to encourage exports. In Europe the opening up of the single market and the Eurozone were effective in reducing national protectionism. Both the US and the EU held down Japanese imports through ‘voluntary’ export quotas in the 1980s and 1990s. This was, however, only a temporary protection. The opening of Japanese transplants in Europe and North America, allied to strong consumer demand for Japanese cars, rendered these restrictions superfluous. Tariff barriers on automobiles are difficult under WTO rules, hence China cut its tariffs on new car imports from 80 per cent to 25 per cent and also increased its import quotas after joining the WTO in 2001 (Maxton and Wormald 2004). However, cutting tariffs does not by itself open up automotive markets. The Japanese abandoned import tariffs on cars in 1978, but their market remains notoriously ‘the most closed auto market in the world’ (Steve Biegum, Ford Vice-President for International Governmental Affairs, Financial Times 2013b), significantly due to strict and particular vehicle testing regulations that raise the costs of vehicle imports.

National and international environmental regulation has become increasingly important, and has acted as a major spur to technological innovation in both sectors, designed to improve engine efficiency, reduce vehicle weights with new, lighter materials, and develop new fuels. In both sectors environmental concern has focused very largely on noxious emissions from vehicles (e.g. carbon monoxide, nitrogen oxides). However, in aerospace there has also been concern about noise pollution, especially around airports, dating back to the 1960s. Because air travel is largely international, the International Civil Aviation Organization has played a key role in developing the regulatory framework, but so have national governments (in particular the US) and increasingly the EU (e.g. the inclusion of aviation in the EU Emissions Trading Scheme in 2012). In automotive the key sources of environmental regulation have been national, or sometimes local, governments (e.g. California, Shanghai), although in Europe the EU has also been a significant player (e.g. setting carbon dioxide reduction targets). California passed the first laws controlling vehicle emissions in 1959, and the California Air Resources Board has played a continuing innovatory role in regulating traffic pollution (e.g. the Zero Emission Mandate for sale of electric and hybrid cars). In the developing world, governments have begun to regulate pollution, but standards tend to be lower, because local manufacturers often cannot meet more challenging standards, existing vehicle owners object, and the necessary infrastructures are unavailable (e.g. a ready supply of unleaded petrol; Sperling and Gordon 2010).

In practice automotive manufacturers have often been more reluctant to introduce greener technologies than their aerospace counterparts. They have argued in the past that such innovations would not work (e.g. catalytic converters, electric cars) and that consumers would not pay for them. Their attitude is understandable in that they have huge investments and sunk costs in existing powertrain technologies that would be rendered obsolete by a technology that replaced the internal combustion engine (Zapata and Nieuwenhuis 2010). However, over time they have developed and successfully introduced quite radical technologies (e.g. replacing carburettors and distributors with fuel injection and electronic engine management systems; Maxton and Wormald 2004), not least under pressure from regulators and consumers. The industry has also radically transformed its production technologies (from mass production, to lean production, to build-to-order production). Nevertheless, the volume of auto manufacturers’ vehicles still use steel-based structures and internal combustion engines. Rising oil prices have helped encourage manufacturers by increasing demand for smaller cars. However, regulation has also had unintended consequences. For example the CAFE (corporate average fuel economy) standards introduced in the 1970s to reduce the size of US automobiles were effective in reducing...
the size of cars, but also drove up demand for SUVs which were not governed by the same regulations. In aerospace it may be argued that cleaner technologies were easier to accept, because lighter aircraft with more efficient engines were clearly a source of competitive advantage when selling to airlines seeking to cut costs. Arguably, airlines were more price sensitive to aircraft running costs than car owners were to automobile running costs. Hence environmental regulation can be seen to be a major driver of technological change in both sectors, but as especially significant in automotive where government R&D subsidies and purchases lack the impact they have in aerospace.

Both industries have been subject to safety regulation for many years, much applying to vehicle users rather than manufacturers (e.g. drivers’ and pilot’s licences). In various other ways, safety regulation in both sectors mirrors environmental regulation. For example, in aerospace ICAO plays a leading role in setting safety standards and reviewing their implementation, while the EU in Europe (through the European Safety Agency) and national governments (e.g. the Federal Aviation Administration in the US) also regulate key areas of the industries’ activities. Critically, safety regulation involves giving type approval to aircraft and cars, and to their components, and without it planes, cars and components cannot go into service. Obtaining type approval makes meeting the requirements of regulators an essential objective for engineers when designing vehicles. However, cars remain much less safe in use than aeroplanes. As with environmental regulation, the automotive industry was not necessarily enthusiastic about safety improvements (e.g. independent crash tests). However, pressure from governments, consumers, insurers and consumer champions (notably Ralph Nader) drove both increased regulation and technological improvement.

The regulation of intellectual property arises in two respects, one affects both sectors, and the other only aerospace. The first, affecting both, is the protection of intellectual property rights (IPRs) (e.g. in an overseas joint venture). This is critical, so that products are not cloned or pirated. The most obvious recent cases in this respect have been in automotive in China, where both GM and Volkswagen have found even whole vehicles have been cloned. The best regulatory protection is likely to be that of the technology importing country, and China has strengthened its IPR laws since joining the WTO. Nevertheless they are widely recognised as weak (Sperling and Gordon 2009), which impacts on their capacity to acquire new technologies (e.g. China attracts markedly fewer foreign aerospace investments for R&D than for manufacturing; Price Waterhouse Coopers 2010). The second aspect of IPR regulation, significant in aerospace, is the refusal of domestic governments to allow their aerospace industries to export products that may lead to the leakage of technology to unfriendly states. This problem is most acute in the US, where government regulations can, for example, restrict sales of civil aircraft that contain a single component designated as restricted under the US International Traffic in Arms regulations. Compliance becomes even more complicated when companies have to meet both US and European technology export regulations. In practice this has led to some SMEs avoiding the more restrictive US regulations by not seeking contracts that involve compliance with them.

Policy impacts: technologies, competitiveness, structure and geography

Technological competitiveness is only one consideration for technology policy makers concerned with the aerospace and automotive industries. These are key industries, both in industrialised and developing societies. Automotive is the largest manufacturing industry, while aerospace is critical for national defence and can drive a range of other technologies. Technology policy here critically affects the achievement of a much wider range of policy objectives, such as exports,
Employment, environmental protection, defence, citizens’ safety and national prestige. Hence, governments adopt a wide range of policy instruments that impact upon the technological development of these industries. In aerospace, Price Waterhouse Coopers (2011: 9) conclude ‘We see the government as playing a key role in driving research priorities in the aerospace sector . . . both through regulation . . . and through joint efforts to promote environmentally-friendly R&D’. Governments do not generally exercise the same degree of control over technology development where automotive manufacturers are well established, as the industry can afford its own R&D, and government is not a key customer. Nevertheless, via regulation governments drive an environmentally friendly agenda. In countries with developing automotive industries, the position is closer to that in aerospace. If they are to overcome high technological and financial barriers to entry, they need consistent government support.

Clearly such policies can directly impact on R&D activities in general as well as individual projects. In aerospace, governments can profoundly influence the direction and pace of technological advance. In military aerospace, government both decides what projects will be pursued as end user, and pays directly for R&D. In civil aerospace, the government is no longer usually the customer, but the character of the industry’s technologies affords it opportunities directly to influence what projects will be pursued and using what policy instruments. Furthermore, regulatory activities set the industry a whole range of R&D priorities (e.g. emissions). In addition military R&D can provide direct spin-offs to aid civil aerospace, though the current decline in US and European military expenditures may reduce its capacity to do so. In the automotive industry, the role of government is less all-embracing, in particular where companies are already established competitors in world markets. But, government regulatory concerns, accompanied by substantial subsidies, are driving longer-term R&D priorities (e.g. lean burn engines). In addition, the official sanctioning, and implementation of non-tariff barriers (e.g. in Korea and Japan) encourages R&D in general, by enabling manufacturers to amortise its costs over longer production runs for domestic markets.

In developing economies, both sectors usually need government support to acquire new technologies. Apart from subsidies, this can be done by restricting imports (as far as the WTO’s credulity will allow), and offering market access in return for access to the necessary technologies. This is most likely to happen for production technologies (as foreign investors are less likely to set up R&D facilities overseas – except to meet particular local market requirements). Nevertheless, much can be learned even on this basis. However, such learning requires government to create the necessary infrastructure of universities, and research laboratories that will provide the highly skilled labour, research facilities, etc. to understand and use the technologies being made available. A developing country’s ability to acquire and use knowledge and skills from overseas, especially if it is unable or unwilling to protect intellectual property, should make potential foreign investors very cautious in deciding how much of their critical IPRs they are willing to transfer, regardless of promises of market access (Price Waterhouse Coopers 2011). In more advanced economies, universities and government research laboratories play a somewhat different role in R&D, focusing more on ‘blue skies’ and ‘leading edge’ research, where they have greater expertise, and where firms are less immediately interested, because paybacks are less clear. Government technology policies play a key role though, both because they fund academic research, and because they fund collaborative, public–private projects designed: to focus academic researchers on projects with potential economic value; to shape public–private interactions; and to facilitate the transfer of research findings into industry.

The aerospace and automotive markets are ones where technological advance is key to product differentiation and hence to competitiveness. Thus, technology policy has a key role to play in influencing the size and shape of the industry. The extent of this influence is somewhat less in
automotive, not least because it is a consumer industry where other factors (e.g. branding) affect competitiveness. In aerospace, government R&D funding is the ‘ticket price’ for competitiveness. Firms cannot afford to pay for enough R&D on their own. In periods of contraction and consolidation (as at present in US and European military aerospace) government policy is critical in determining not only what technologies will be pursued, but which companies will be allowed to pursue them, and what will be the resulting structure of the industry. Clearly, this involves broader considerations than technology policy, but decisions about industrial policy, employment policy and regional policy have to be taken in a technology policy context.

In the automotive industry the role of technology is more contingent, both on the strength and competitiveness of the industry, and the broader context of public policies. Where firms are internationally competitive and profitable, they can in principle pay for the technology necessary to design and manufacture their next generation of vehicles. However, in market conditions of over supply and falling profit margins, this is likely to apply to fewer manufacturers. It is unlikely to apply to new entrants to the industry in developing economies. Perhaps the most interesting contra-indication to this is the Indian Tata Group that has both developed the Nano car for the domestic market and gained access to advanced technologies by buying Jaguar and Land Rover from Ford. For developing economies, possessing a competitive, indigenous aerospace or automotive industry can play an important role in national economic development and industrialisation. But the experience of the Malaysian automobile industry illustrates the challenges of trying to enter such industries as a primary manufacturer. Ultimately, few nations are likely to have the domestic markets, or technological and industrial capabilities necessary. China may well achieve autonomy in both industries. India, through Tata, may do so in automotive, but seems less likely to do so in aerospace. Russia has a major aerospace sector, but whether it can become a global player in aerospace or automotive markets is unclear. Perhaps the most interesting developments in either sector are the current Brazilian, Chinese, Russian, Japanese and Canadian attempts to enter the single-aisle airliner market to compete with the A320 and Boeing 737. Were one (or more) of these to prove internationally successful, it would represent, inter alia, a remarkable achievement of technology policy.

Looking at technology policy beyond the strict confines of the automotive and aerospace industries, the trajectories of technological development in both offer the prospect of spin-off technological and economic benefits into adjacent sectors. Aerospace, in particular, has generated a wide range of technological advances that benefit other sectors (e.g. wind turbines). If anything, the trend of technological developments in both sectors, which has seen Tier 1 and 2 suppliers adopting more salient roles, enhances the opportunities for inter-sectoral spin-offs, because these suppliers may already be serving other sectors.

Finally, it is important to recognise that technology policy impacts upon the geography of the aerospace and automotive industries in two distinct ways. First, the security implications of aerospace are such that its R&D has a distinctly national or continental focus. In practice, the commercial aircraft industry is dominated by two essentially continental industries in Europe and the US. In military aviation Governments wish to retain their own R&D capabilities at home, within their borders and being conducted by indigenous companies but, as EADS illustrates, very few states have this capability. In automotive, the lack of security considerations has allowed a somewhat more international approach in R&D. International mergers and acquisitions permit R&D to be conducted in one location but to be freely disseminated internationally within the company. Equally, companies that set up major manufacturing facilities abroad can readily set up R&D facilities there, even if only to serve a particular, local market. Nevertheless, there is strong evidence of continentalisation in automotive (e.g. European manufacturers moving production to the EU periphery; US manufacturers moving production.
to Mexico). Assembly transplants (e.g. German and Japanese assembly plants in the US) are built to serve continental markets, while core design and engineering functions are retained in the company’s ‘home’ market (Sturgeon et al. 2008). Second, both industries demonstrate the importance of clustering. Such clusterings can involve leading manufacturers, their suppliers, and supporting R&D facilities (company, university and government run). The development of such clusters is likely to be, at least in large part, a function of public policy. The best single example is probably Toulouse, which became France’s hub for civil aerospace as a result of a deliberate act of public policy (Hickie 2006).

What this brief review of the automotive and aerospace industries illustrates is the range of policy instruments governments can use to influence, and even drive, technology development in both sectors. Furthermore it demonstrates how a judiciously focused technology policy, determinedly pursued over time, can impact upon: the direction, focus and pace of technology development; the international competitiveness and structure of both sectors; and the capacity of governments to retain or develop internationally successful manufacturers in either sector.

References


