

ORIGINAL ARTICLE

The Adverse Effects of Technological Innovation under WTO Subsidy Rules

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Abstract

The WTO concluded in 2012 that subsidized aeronautical research and development (R&D) gave Boeing a head start in product development that caused serious prejudice to the interests of Airbus but later, in 2019, it could not decide how long that head start had lasted. Meanwhile, the WTO concluded in 2018 that launch aid for Airbus aircraft led to innovations that also improved later aircraft models, thereby contributing to serious prejudice to the interests of Boeing. Both conclusions relied on a causation analysis that considered the effects of technological innovation, which makes subsidies used for R&D particularly vulnerable to challenge. This novel analysis may be too broad for the actionable subsidy disciplines of the SCM Agreement.

Keywords: innovation; research and development (R&D); subsidies; SCM Agreement; aircraft; Airbus; Boeing; WTO

1. Introduction

Technological innovation is a major driver of economic growth¹ and vital to addressing societal challenges such as climate change, health, and food security. Yet WTO subsidy rules are now being interpreted in a way that could restrain technological progress. The issue first arose in the long-running US large civil aircraft dispute,² which chiefly concerns the launch of a technologically superior aircraft (the Boeing 787 Dreamliner) for around the same price as the then-incumbent market leader (the Airbus A330).³ Under the rules of the WTO Agreement on Subsidies and Countervailing Measures (SCM Agreement), this is regarded as a problem that needs a solution. The reason is that some of the research and development (R&D) that led to the technologies used on the 787 received government support. In 2012, the WTO actually granted a remedy to protect the manufacturer of the less fuel-efficient, superseded aircraft.⁴ Subsequently, in the EU large civil aircraft dispute, the WTO found against launch aid to the rival manufacturer, partly because it had improved the technology on the A350XWB through lessons learnt in the development of earlier aircraft models.⁵

¹Solow (1957).

²*United States – Measures Affecting Trade in Large Civil Aircraft (Second Complaint) (US–Boeing)*, WT/DS353. The first complaint (WT/DS317) did not lead to a panel report.

³Panel Report, *US–Boeing*, WT/DS353/R, para. 7.1785.

⁴Appellate Body Report, *US–Boeing*, WT/DS353/AB/R, paras. 1350(d)(i) and 1352.

⁵Appellate Body Report, *EC and Certain Member States – Large Civil Aircraft (EC–Airbus) (Article 21.5 – US)*, WT/DS316/AB/RW, para. 6.22.

The underlying rationale treats technological innovation itself – not just expenditure on R&D – as a mechanism that causes ‘adverse effects’ and ‘serious prejudice’.⁶ The causal link between a subsidy and adverse effects is an essential element of an actionable subsidy claim. In *US–Boeing*, the WTO accepted that R&D subsidies could cause serious prejudice to the interests of a competitor not only by reducing a beneficiary’s costs of production and giving it an edge in price competition but also by improving the beneficiary’s product and giving it a head start in innovation competition.⁷ This ‘technology effects’ analysis can challenge the introduction of new or improved products and processes that reach the market earlier than they could have done without subsidy, where this harms the trade interests of another WTO Member. By the same logic, had a smartphone operating system been developed with even modest government support, that could have been challenged on the ground that its improved functionality shrank the market for flip phones.

This paper begins by describing the technology effects analysis as it emerged in *US–Boeing* and the indirect learning effects analysis applied in *EC–Airbus*. It examines the presumed legal basis for this wide interpretation of the SCM Agreement and then explores whether a narrower interpretation of the rules and remedies is appropriate. The paper also considers whether the SCM disciplines offer effective relief in dynamic high technology markets. Finally, the paper looks ahead to consider how future cases could treat subsidies for R&D differently.

Technology is relevant to other aspects of the large civil aircraft cases that are not considered here. The panel in *EC–Airbus* found that a raft of government R&D grants and loans complemented and supplemented the serious prejudice caused to Boeing by launch aid for Airbus, although this conclusion was reversed on appeal for lack of detail.⁸ The panel in *US–Boeing* found that government R&D contracts, which provided payments and access to facilities, equipment, and employees, constituted subsidies, and this conclusion was upheld on appeal.⁹ The panel in *US–Boeing* also found that the waiver or transfer of patent and data rights in publicly funded research under the Bayh-Dole Act¹⁰ was not specific, and therefore not actionable (if, indeed, it was a subsidy at all), but that finding was not sustained on appeal.¹¹ These aspects of the large civil aircraft cases all lie outside the scope of this paper.

2. Technology and Learning Effects in the Large Civil Aircraft Cases

This section describes the technological innovations at issue in the *US–Boeing* dispute and explains the ‘technology effects’ analysis that led to the crucial finding that the subsidized R&D caused serious prejudice to Airbus. It also examines a similar ‘learning effects’ analysis in the compliance proceeding of the *EC–Airbus* dispute. It then traces the limits of the technology effects analysis as exposed during the compliance proceeding in *US–Boeing* and recalls the concerns regarding these causation analyses expressed by third parties.

⁶Serious prejudice is a form of ‘adverse effects’ under Article 5(c) of the SCM Agreement (see Section 3.1 below). This paper generally uses the term ‘serious prejudice’ to distinguish clearly from the ‘price effects’, ‘financial effects’, and ‘technology effects’ causal mechanisms.

⁷A ‘head start’ allows a competitor in a race to start earlier than other competitors.

⁸The R&D subsidies at issue were EC Framework Programmes for Community Activities in the Field of Research and Technological Development and Demonstration Activities as well as French, German, and UK government grants and Spanish government loans. See Appellate Body Report, *EC–Airbus*, WT/DS316/AB/R, paras. 1401–1409.

⁹See Appellate Body Report, *US–Boeing*, paras. 550–666.

¹⁰35 U.S.C., paras. 200–212 (Patent Rights in Inventions Made with Federal Assistance), and related measures.

¹¹See Panel Report, *US–Boeing*, paras. 7.1276–7.1312; Appellate Body Report, *US–Boeing*, paras. 790–800. The appeal on this point only raised patents, not data rights.

2.1 Technologies at Issue in US–Boeing

The technologies at issue in *US–Boeing* are features on jet aircraft and processes for their design and manufacture. They were first applied to the Boeing 787 Dreamliner and then to later models of aircraft, such as the 787/9-10, 777X, and 737 MAX.

The most important technologies at issue concern the composite structures used in the fuselage and wings on the 787.¹² Composite materials such as graphite can improve aircraft performance and lower operating costs for the customer because they weigh less than aluminium but their high manufacturing costs presented an enduring technical problem. Innovations such as the accelerated processes for production of composite materials, including mouldings, made the use of composites in large components, such as fuselages, cost-effective in large civil aircraft.

A range of other innovative technologies is also at issue, notably (a) the more-electric architecture of the 787 uses electrical power to drive secondary mechanical systems instead of a combination of hydraulic, pneumatic, and electrical power, thereby reducing maintenance and lowering overall fuel consumption; (b) the open systems architecture of the 787 allows for easier upgrading of aircraft functionality and alleviates some of the hardware; (c) enhanced aerodynamic and structural design technologies, including software, used in the design, production and assembly processes led to specific improvements in the 787's wings; (d) noise reduction technologies; and (e) health management systems to monitor the different parts of an aircraft and reduce maintenance costs.¹³ None is a disruptive technology that would radically alter aircraft operational characteristics, such as size or speed.

The use of these technologies on the Boeing 787 Dreamliner prompted Airbus to design a more technologically advanced aircraft to compete with it. The A350XWB was built with advanced materials, including carbon composites, although it has a more conventional fuselage design and systems architecture than the 787. The A350XWB also has lower operating costs, fuel burn, and carbon dioxide emissions when compared with previous generation aircraft.¹⁴

The innovations at issue in *US–Boeing* solved important technical problems in the aeronautical industry by, for instance, increasing fuel-efficiency. The European Union raised these innovations in a challenge under Part III of the SCM Agreement¹⁵ because they were developed with support from the National Aeronautics and Space Administration (NASA) and the US Department of Defense (DoD).¹⁶ The challenge was a counter-complaint to the United States' complaint regarding launch aid and other subsidies in *EC–Airbus*.¹⁷

2.2 Technology Effects in the Original US–Boeing Proceeding

A central claim in *US–Boeing* is that US government aeronautical R&D programs subsidized the development of the technologies at issue and that this aided Boeing and caused serious prejudice to Airbus.¹⁸ An important aspect of the case is that the intermediate, positive effects of these subsidies on Boeing aircraft were framed in the claims not only in terms of the money saved on Boeing's product development costs, which might pass through to lower aircraft prices (price effects), but also on the basis of the value of the technological advancements obtained from

¹²Panel Report, *US–Boeing*, para. 1702.

¹³Panel Report, *US–Boeing*, paras. 7.1702–7.1740, 7.1749–7.1764 and Appendix VII:F.1; Appellate Body Report, *US–Boeing*, para. 970; Panel Report, *US–Boeing (Article 21.5)*, para. 9.139. Additional technologies were raised in the compliance proceeding: see note 59 below.

¹⁴A Natural Revolution in Design', www.airbus.com/aircraft/passenger-aircraft/a350xwb-family.html.

¹⁵Claims were also filed under Part II of the SCM Agreement, but as regards other measures.

¹⁶Subsidies allegedly provided by Japan were outside the scope of the WTO dispute.

¹⁷The initial request for consultations (WT/DS317/1) was filed within hours of the request for consultations in *EC–Airbus* (WT/DS316/1).

¹⁸Claims must allege serious prejudice to the interests of another 'Member' but, in this case, Airbus and Boeing are the only manufacturers of large civil aircraft in the European Union and the United States, respectively.

the R&D itself (technology effects).¹⁹ Viewed from the latter perspective, the subsidies gave Boeing a head start in developing the innovations that made the 787 a better aircraft, which reduced demand for competing products in the 200–300 seat market, resulting in lost sales, lower prices, and fewer exports of Airbus aircraft.

The panel found that Boeing's work on R&D contracts funded by eight NASA programs²⁰ and one DoD program²¹ made a genuine and substantial contribution to Boeing's accelerated development of technologies used on the 787. On appeal, the R&D contracts were found to be subsidies due to a non-market-consistent allocation of intellectual property rights.²² The work was early stage, high-risk aeronautical research that complemented Boeing's internal product development efforts.²³ Some of the work was directed to finding solutions to specific technological problems later used on the 787 while other work was part of a 'single process of iterative learning and advancement in pursuit of a common technological goal'.²⁴ The panel did not evaluate the effect of each technology separately but concluded that, absent the aeronautical R&D subsidies, Boeing would not have been able to launch an aircraft incorporating all of the technologies on the 787 when it actually did in 2004, with promised deliveries commencing in 2008.²⁵

The characterization of the effects of the R&D subsidies by their impact on Boeing's technology could multiply the effects of these subsidies on Airbus for the purposes of the serious prejudice analysis. This was important because the amount of the subsidies, though large in absolute terms,²⁶ was dwarfed by the amounts involved in producing large aircraft.²⁷ It would have been difficult to show that the cash amount of R&D subsidies, viewed as reductions in Boeing's product development costs, translated into any kind of meaningful price advantage for Boeing aircraft when they were not directly related to prices or sales.²⁸ However, the complainant argued that the R&D subsidies had a 'multiplier effect' when assessed on the basis of the value of the R&D results to Boeing. This value took account of the knowledge and experience that Boeing engineers gained by undertaking R&D in cooperation with NASA and DoD engineers, including access to research and testing facilities, which gave Boeing a head start in its own related R&D activities.²⁹ The strategic importance of this argument for the complainant lay in the way that the multiplier increased the magnitude of the effects of subsidies for Boeing relative to those at issue in the complaint against Airbus.³⁰

¹⁹Panel Report, *US–Boeing*, para. 7.1760; Appellate Body Report, *US–Boeing*, paras. 1005–1007. The complainant argued that the R&D subsidies had both types of effects: see paras. 7.1600 and 7.1605. Other claims were based on the price effects of tied tax subsidies, which are beyond the scope of this paper.

²⁰NASA Advanced Composites Technologies Program, Advanced Subsonic Technology Program, Research and Technology Base Program, High Speed Research Program, Computational Aerosciences Project of the High Performance Computing and Communications Program, Aviation Safety Program, Quiet Aircraft Technology Program, and Vehicle Systems Program: see Panel Report, *US–Boeing*, para. 7.1701, fn. 3583.

²¹DoD Research, Development, Test and Evaluation program. The complainant challenged both science and technology/general aircraft program elements and systems acquisition/military aircraft program elements. The panel found that two of the former had 'technology effects': see Panel Report, *US–Boeing*, para. 7.1148. See further Panel Report, *US–Boeing (Article 21.5)*, paras. 8.301–8.302.

²²Appellate Body Report, *US–Boeing*, paras. 662–666.

²³Panel Report, *US–Boeing*, para. 7.1742.

²⁴Panel Report, *US–Boeing*, para. 7.1750.

²⁵Panel Report, *US–Boeing*, para. 7.1775. Absent the aeronautical R&D subsidies, Boeing would have had to either launch the 787 later than 2004 or launch an aircraft incorporating fewer new technologies in 2004.

²⁶The best estimate was at least \$2.6 billion from NASA during the period 1989–2006, comprising payments of \$1.05 billion and access to facilities, equipment and employees worth \$1.55 billion: see Panel Report, *US–Boeing*, para. 7.1109. The total amount of any DoD subsidy for the period 1991–2006 was not significantly less than \$308 million and may have been much more: see Panel Report, *US–Boeing*, paras. 7.1205–7.1206.

²⁷See Panel Report, *US–Boeing (Article 21.5)*, para. 9.55. See also para. 9.288.

²⁸Panel Report, *US–Boeing*, paras. 7.1760 and 7.1807.

²⁹Panel Report, *US–Boeing*, paras. 4.331 and 7.1633.

³⁰Note, for example, the EU statement upon adoption of the reports in *US–Boeing*, note 43 below, at para. 75, and the US reply that NASA research only caused adverse effects in the 200–300 seat aircraft segment of the market whereas launch aid caused adverse effects in all segments, at para. 78.

The panel in *US–Boeing* accepted a causation analysis based on the ‘technology effects’ of the R&D contracts without extensive argument on the legal merits.³¹ The panel’s primary justification for this approach was that the nature of the R&D subsidies was intended to multiply the benefit from a given expenditure.³² The panel also made the factual observation that competition in the large civil aircraft market was based on innovation.³³ The parties’ arguments focused on factual questions regarding the degree to which the commissioned R&D work had contributed to the development of the 787 technologies.³⁴ However, the respondent did not challenge the legal basis for this type of causation analysis.

The panel found that the ‘technology effects’ of the aeronautical R&D subsidies to Boeing caused serious prejudice to Airbus. The superior technology and lower operating costs of the 787, as well as its scheduled delivery dates from 2008, caused Airbus to lose a significant number of orders during the period from 2004 (when the 787 was launched) to 2006 (when the panel was established). This significantly suppressed the prices of the A330 and A350 during the same period because Airbus had to lower prices to secure other sales in the 200–300 seat aircraft market.³⁵ That threatened to displace and impede future Airbus exports to certain third country markets when the orders booked from 2004 to 2006 were eventually delivered from 2008.³⁶ Significant price suppression and lost sales, and threat of displacement of, and impediment to, exports constitute ‘serious prejudice’ under Article 6.3(b) and (c) of the SCM Agreement. The ‘price effects’ of certain federal, state, and local tax subsidies tied to aircraft sales were analysed separately.³⁷

The appeal did not alter the causation findings significantly. The United States argued that the causal link between NASA research and Boeing’s launch of the 787 in 2004 was attenuated because the amount of the R&D subsidies was relatively low, rather than because their effects on the market were technological.³⁸ The Appellate Body saw no reason to find that the amount of the R&D subsidies diminished their important contribution to the development of the technologies on the 787.³⁹ The finding on threat of displacement and impediment was narrowed to one third country market.⁴⁰

The panel in *US–Boeing* found that US government R&D support to Boeing was subsidized and that these subsidies caused serious prejudice to the interests of Airbus, *not* because the 787 was less expensive to purchase than the A330 (it was not),⁴¹ but rather because the 787 was a technologically superior aircraft. The Dispute Settlement Body (DSB) recommended that the United States withdraw these subsidies or remove their adverse effects within six months.⁴² The implementation period ended in September 2012 and the dispute was promptly referred back to the panel to assess the United States’ compliance with the DSB recommendation.

³¹The causation analysis regarding the other subsidies at issue was based on price effects: see Panel Report, *US–Boeing*, paras. 7.1798–7.1834. The complainant indicated that the panel should not over-count the effects of the R&D subsidies by analysing both their technology effects and price effects: see para. 7.1826.

³²Panel Report, *US–Boeing*, paras. 7.1759–7.1760.

³³Panel Report, *US–Boeing*, paras. 7.1765–7.1769; cf. findings at note 35 below, which show that competition was also based on price.

³⁴Panel Report, *US–Boeing*, para. 7.1749. See also para. 7.1750.

³⁵Panel Report, *US–Boeing*, paras. 7.1780 *et seq.* Price ‘suppression’ means preventing price increases that would have occurred otherwise.

³⁶Panel Report, *US–Boeing*, para. 7.1797.

³⁷Panel Report, *US–Boeing*, paras. 7.1798–7.1834; Appellate Body Report, *US–Boeing*, paras. 1146–1274 and, regarding a cumulative assessment of the R&D subsidies and certain tax subsidies and their effects: paras. 1302–1321.

³⁸Appellate Body Report, *US–Boeing*, para. 1003.

³⁹Appellate Body Report, *US–Boeing*, paras. 1007–1011. See also para. 1035.

⁴⁰Appellate Body Report, *US–Boeing*, paras. 1083–1090. The Appellate Body also considered that it would have been appropriate to consider the combined price effects and technology effects of the different subsidies at issue in the dispute: paras. 1313–1321.

⁴¹The operating costs (for customers) were lower than those of competitive aircraft but these are different from the manufacturing costs (for the producer).

⁴²WT/DSB/M/313, item 5.

2.3 Learning Effects in the EC–Airbus Compliance Proceeding

Technology effects crossed over to the other large civil aircraft case. Rather than challenge the possibility that technology could have a ‘multiplier effect’ for the purposes of SCM disciplines in *US–Boeing*, the United States suggested that launch aid might have a multiplier effect in *EC–Airbus*.⁴³

As complainant in that other dispute, the United States claimed that launch aid and other subsidies caused serious prejudice to Boeing because they ‘facilitated and accelerated’ the introduction of whole models of aircraft (product effects)⁴⁴, and also led to lower prices (price effects).⁴⁵ In the original proceeding, ‘product effects’ were partly based on learning curve advantages gained from producing successive models of aircraft, insofar as they reduced costs.⁴⁶ The original panel found ‘product effects’ based on the economic effects of reducing costs and shifting risks⁴⁷ and it cited economic literature that explained the impact of learning curve effects on marginal costs of production.⁴⁸

However, during the compliance proceeding in *EC–Airbus* (which occurred after the original *US–Boeing* proceeding),⁴⁹ the complainant submitted that launch aid had ‘technology and learning effects’ where there was ‘a transfer of technology, knowledge, and production processes that benefit subsequent aircraft programs and that otherwise would not exist’.⁵⁰ It distinguished between the financial effects and the technological effects of launch aid on the A350XWB⁵¹ and submitted that this was consistent with the original panel’s findings.⁵² The respondent disputed the technology connections between different aircraft as a factual matter,⁵³ but it did not challenge the legal basis of this causation analysis, presumably because of its position as complainant in the counter-complaint.

The compliance panel distinguished the subsidies’ indirect ‘learning effects’ from their ‘financial effects’⁵⁴ and identified various technological and managerial innovations that flowed from the subsidized production of the A380 and other aircraft to the A350XWB.⁵⁵ Some of these were product features, such as a wings high-lift system, hydraulic pressure levels, flight control architecture, and derivations of components and systems. The compliance panel treated these innovations as a means of transmission of serious prejudice⁵⁶ and the Appellate Body agreed.⁵⁷

⁴³Ibid., para. 78.

⁴⁴Panel Report, *EC–Airbus*, paras. 7.1865 and 7.1879–7.1996.

⁴⁵Panel Report, *EC–Airbus*, paras. 7.1997–7.2024.

⁴⁶See *EC–Airbus*, US second written submission, para. 634, arguing that technology spillovers from one aircraft model to another reduced development and production costs, followed up in US response to panel question no. 166.

⁴⁷Panel Report, *EC–Airbus*, para. 7.1954. The United States had also submitted that competition between Boeing and Airbus was driven by aircraft performance characteristics as well as price: see para. 4.384.

⁴⁸Panel Report, *EC–Airbus*, para. 7.1717; para. 7.1726, fn 5208; para. 7.1936, fn 5643; para. 7.1940, fn 5657; and para. 7.1948, citing Klepper (1990) and Neven and Seabright (1995).

⁴⁹The reports in *US–Boeing* were adopted on 23 March 2012. The substantive meeting with the compliance panel in *EC–Airbus* was held on 16–18 April 2013.

⁵⁰*EC–Airbus (Article 21.5 – US)*, United States second written submission, para. 401.

⁵¹*EC–Airbus (Article 21.5 – US)*, Annex B-3, para.13.

⁵²*EC–Airbus (Article 21.5 – US)*, United States second written submission, para. 556, citing a sentence regarding technical capabilities in the original panel report at para. 7.1948, as reviewed in the original Appellate Body Report at paras. 1353–1355. For its part, the compliance panel cited a statement regarding product features in the original panel report at para. 7.1935 (sourced from the US response to a panel question in note 46 above): see Panel Report, *EC–Airbus (Article 21.5 – US)*, para. 6.1448, fn 2447.

⁵³Panel Report, *EC–Airbus (Article 21.5 – US)*, Annex C-1, para. 49; Annex C-2, para. 25.

⁵⁴Panel Report, *EC–Airbus (Article 21.5 – US)*, paras. 6.1492 and 6.1510–6.1511.

⁵⁵Panel Report, *EC–Airbus (Article 21.5 – US)*, paras. 6.1747–6.1760. As regards the characterization of the original panel’s findings, see Appellate Body Report, *EC–Airbus (Article 21.5 – US)*, paras. 5.637, 5.639, and 5.643.

⁵⁶Panel Report, *EC–Airbus (Article 21.5 – US)*, paras. 6.1774 and 6.1817.

⁵⁷Appellate Body Report, *EC–Airbus*, para. 5.637.

This formed part of the basis for the conclusion that launch aid continued to cause serious prejudice.⁵⁸

2.4 Technology Effects in the US–Boeing Compliance Proceeding

The limitations of the technology effects analysis were exposed during the compliance proceeding in *US–Boeing*. At the compliance stage of that dispute, the complainant raised more technologies used on Boeing aircraft⁵⁹ and presented more ‘technology effects’ arguments.⁶⁰ The compliance panel applied the same causation analysis as in the original proceeding⁶¹ but it led to opposite results. These the compliance panel attributed to differences in timing: timing of the research, timing of the application of technology, or timing of the dispute itself.

Before the compliance panel, the complainant unsuccessfully argued that the technologies at issue in the original proceeding, such as the composite fuselage and wing design of the 787, were continuing to cause serious prejudice to the Airbus A350, since redesigned as the A350XWB. The compliance panel rejected this argument because the technology effects in the original proceeding only comprised the head start that subsidized R&D gave Boeing, not the technologies themselves. The compliance panel described this as the ‘acceleration effect’ of the subsidies. These technologies could have come into existence even without subsidized R&D, although they would have reached the market later than 2004, when the 787 was actually launched.⁶² The compliance panel did not calculate the precise length of the head start because it decided that, in any case, the 787 could have been launched without subsidized R&D long before the end of the implementation period in 2012.⁶³ The Appellate Body considered that the head start might have continued until the first delivery date but, not knowing when that would have occurred without subsidy, it could not decide whether the technology effects had ceased by 2012 or not.⁶⁴ For the same reason, the complainant was unsuccessful in arguing that the adaptation of the 787 technologies to more recent Boeing aircraft caused serious prejudice to the A350XWB and A320neo.⁶⁵

Certain other findings were not appealed. The complainant had failed to persuade the compliance panel that so-called ‘sleepers’ technologies, based on earlier research but which had matured since the original proceeding, were also causing serious prejudice to the A350XWB.⁶⁶ The complainant also failed to demonstrate new technology effects based on later research funded by the same programs at issue in the original proceeding or later programs.⁶⁷

Although the technology effects analysis in *US–Boeing* had allowed the claims regarding R&D subsidies to prevail in the original proceeding, it did not lead to any remedy in the compliance proceeding more effective than the passage of time.

⁵⁸ Appellate Body Report, *EC–Airbus*, paras. 6.22 and 6.42(a).

⁵⁹ The technologies included a scaled-up composite wing design to provide a fuel-burn advantage, a drag reduction technique to increase fuel-burn savings, radio frequency identification tagging to improve aeroplane health management systems, and the incorporation of a folding wing tip design to achieve airport compatibility: see Panel Report, *US–Boeing (Article 21.5)*, paras. 9.179, 9.187, 9.203, and 9.208. Other technologies inspired by the 787 are used on the 737 MAX, including the engine integration design, enhanced aerodynamics, and modern flight controls: see para. 9.344.

⁶⁰ Given that more recent R&D had so far yielded few commercially applicable innovations, the complainant only argued ‘price effects’ for most of the later subsidies.

⁶¹ In the compliance proceeding, this was described as a ‘technology causal mechanism’.

⁶² Panel Report, *US–Boeing (Article 21.5)*, para. 9.203.

⁶³ Panel Report, *US–Boeing (Article 21.5)*, para. 9.176.

⁶⁴ Appellate Body Report, *US–Boeing (Article 21.5)*, paras. 5.416, 5.442–5.443.

⁶⁵ Appellate Body Report, *US–Boeing (Article 21.5)*, paras. 5.420. These so-called ‘spillover’ effects refer to 787 technologies applied to other Boeing aircraft rather than to knowledge spillovers to other firms.

⁶⁶ Panel Report, *US–Boeing (Article 21.5)*, para. 9.197.

⁶⁷ Panel Report, *US–Boeing (Article 21.5)*, paras. 9.216–9.217. This concerns the NASA Fundamental Aeronautics Program; Integrated Systems Research Program; Aviation Safety Program; Aeronautics Test Program; additional science and technology/general aircraft elements of the DoD RDT&E program; and the FAA Continuous Lower Energy, Emissions and Noise (CLEEN) Program.

2.5 Concerns Expressed Regarding These Causation Analyses

Two third parties contested the legal basis for technology or learning effects under the disciplines of the SCM Agreement but their concerns were not addressed, partly for reasons of timing.

During the *EC–Airbus* and *US–Boeing* compliance proceedings, Japan argued that serious prejudice should stem primarily from the pricing policy of a subsidy recipient and not from its development of new technology. Japan submitted that it was more practical to limit the remedy of removal of adverse effects to price effects.⁶⁸ In the *US–Boeing* compliance proceeding, Korea argued that technology effects were difficult to reconcile with the structure of the SCM Agreement and its definition of a subsidy. Korea noted that the financial effects of a subsidy are quantifiable and remediable whereas the technological effects were not. Korea submitted that the assessment of serious prejudice on the basis of a technology causal mechanism should be carefully circumscribed, if not entirely rejected.⁶⁹

By the time that these third parties raised their concerns, the original panel in *US–Boeing* had already adopted an analysis based on technology effects and that had been upheld on appeal. A rejection of the technology effects causation analysis at the compliance stage of that dispute would have contradicted the original panel and required the compliance panel to deviate from adopted findings in the same dispute.

The question has been left hanging as to how the technology and learning effects⁷⁰ causal mechanisms are permitted by the serious prejudice disciplines of the SCM Agreement. A wide interpretation may have been attractive in the large civil aircraft cases because the subsidies at issue in both proceedings had similar adverse effects. However, those cases concern the competitive subsidization of a duopoly. This type of interpretation should be carefully considered before it is applied to claims involving other products and industries.

3. How Subsidies Cause Serious Prejudice

Unlike previous disputes, the large civil aircraft cases partly analyse the cause of serious prejudice via technology or learning effects.⁷¹ The principal parties, panels, and the Appellate Body all seem to have accepted a wide interpretation of the causal link required under WTO rules that covered non-financial effects of subsidies. They appear to have assumed that the type of subsidies at issue or the conditions of competition in the relevant markets, or both, permitted this approach. This section examines how the SCM Agreement could be construed in such a way, and then considers whether a narrower interpretation is called for.

3.1 Any Effects that Confer a Competitive Advantage

The text of Part III of the SCM Agreement focuses on the effects of actionable subsidies rather than on the way in which those effects are caused. The grounds for claim and one of the remedies are based on adverse effects rather than on the nature of the subsidy (unlike prohibited subsidies) or on numerical expenditure limits (unlike agricultural domestic support).⁷² Even though the

⁶⁸Panel Report, *EC–Airbus (Article 21.5 – US)*, Annex D-9, paras. 12–16; Panel Report, *US–Boeing (Article 21.5)*, para. 9.285; Annex D-5, paras. 2–9.

⁶⁹Panel Report, *US–Boeing (Article 21.5)*, para. 9.286; Annex D-7, paras. 16–17; Annex D-8, paras. 15–17.

⁷⁰Learning effects in the sense of innovation rather than reduced costs.

⁷¹Cf. *Indonesia – Certain Measures Affecting The Automobile Industry (Indonesia–Autos)*, WT/DS59/R, para. 14.255 (where causation was effectively conceded); *United States – Subsidies on Upland Cotton (US–Upland Cotton)*, WT/DS267/R, paras. 7.1347–7.1355; *Korea – Measures Affecting Trade in Commercial Vessels*, WT/DS273/R, para. 7.678; *US–Upland Cotton (Article 21.5)*, WT/DS267/RW, paras. 10.228–10.239, 10.247–10.254.

⁷²Cf. SCM Agreement, Article 3; Agreement on Agriculture, Article 6.

actionable subsidies disciplines do not exclusively concern effects,⁷³ this may permit a wide interpretation of the possible mechanisms that transmit effects from subsidies to markets.

Effects are what make a subsidy actionable, which means that causation is an important element of a claim,⁷⁴ but the SCM Agreement does not explain how to analyse the causal link. Article 5 provides an obligation not to 'cause' adverse effects to the interests of other Members through the use of any subsidy, and adverse effects include 'serious prejudice'. Article 6.3 describes serious prejudice in terms of certain market phenomena, each of which must be the 'effect' of the subsidy.⁷⁵ Article 6.7 provides a non-exhaustive list of other factors to which serious prejudice must not be attributed in certain cases. The rest of Article 6 addresses the existence of serious prejudice and the development of a factual record, rather than the way in which serious prejudice is caused.⁷⁶

The parsimonious treatment of causation in Part III of the SCM Agreement, on actionable subsidies, means that even a requirement as basic as a 'genuine and substantial' relationship of cause and effect between a subsidy and serious prejudice, has to be inferred.⁷⁷ The lack of detail in the text contrasts with Part V of the same agreement, on countervailing measures, in which Article 15.5 imposes an express obligation on a national authority to demonstrate a causal relationship between the subsidized imports and injury and sets out a non-attribution requirement.⁷⁸

The lack of guidance in the treaty text has been interpreted as a grant of discretion to choose an appropriate method to analyse the causal link. The Appellate Body Report in *US-Upland Cotton* inferred 'that a panel has a certain degree of discretion in selecting an appropriate methodology for determining whether the "effect" of a subsidy' is a form of serious prejudice.⁷⁹ That comment was made in the context of an analysis of financial effects on production and prices. A 'methodology' refers to the factors and factual circumstances that a panel can take into consideration when analysing the subsidy and its effects. The factors typically include the nature and magnitude of the subsidy, the definition of the relevant market, the market power of the subsidizing Member, and evidence of temporal correlation between subsidization and serious prejudice.⁸⁰ The analysis can (in some cases, must⁸¹) include a counterfactual that compares the actual market situation with the situation that would have existed in the absence of the challenged subsidy.⁸² Few limits to the panel's discretion to choose a methodology have been implied, and those that have been usually originate in trade remedy law. The main one is the requirement to conduct a non-attribution analysis to see whether other factors attenuate the causal link between the subsidy at issue and serious prejudice to the point where the causal relationship between them cannot be considered 'substantial'.⁸³

⁷³It can be noted that the definition of 'subsidy' requires an *ex ante* assessment of benefit (see Appellate Body Report, *EC-Airbus*, paras. 706 and 838) and one remedy consists of withdrawal of the subsidy altogether.

⁷⁴The position is unlike the analysis of, say, national treatment claims, where no actual effects are required: see Appellate Body Report, *Brazil-Certain Measures Concerning Taxation and Charges*, WT/DS472/AB/R, separate opinion, para. 5.136.

⁷⁵Article 6.2 also addresses the possibility that a subsidy has not 'resulted' in any of the effects in Article 6.3.

⁷⁶Articles 6.4, 6.5, 6.6, 6.8, and Annex V elaborate on the assessment of the existence of serious prejudice.

⁷⁷Appellate Body Report, *US-Upland Cotton*, WT/DS267/AB/R, para. 438; Appellate Body Report, *US-Upland Cotton* (Article 21.5), WT/DS267/AB/RW, para. 374; Appellate Body Report, *EC-Airbus*, para. 1232. These decisions are inspired by other trade remedy law: see SCM Agreement, Article 15.5, and Anti-Dumping Agreement, Article 3.5. See also Agreement on Safeguards, Article 4.2(b). Cf. the special safeguard mechanism for agricultural products which dispenses with a causation analysis because it provides for volume and price triggers: Agreement on Agriculture, Article 5.

⁷⁸See further Clarke and Horlick (2005) at 733–734.

⁷⁹Appellate Body Report, *US-Upland Cotton*, para. 436; Appellate Body Report, *US-Upland Cotton* (Article 21.5), para. 370; Appellate Body Report, *EC-Airbus*, para. 1232.

⁸⁰However, a precise quantification of the subsidy is not required because the remedy is not an additional duty limited to the amount of the subsidy: Appellate Body Report, *US-Upland Cotton*, paras. 461–467.

⁸¹Trade impediment and price suppression inherently involve a comparison with a hypothetical situation.

⁸²A counterfactual requires the use of economic modelling: Appellate Body Report, *EC-Airbus*, para. 1110.

⁸³Appellate Body Report, *US-Upland Cotton*, para. 436.

This has led to a case-by-case approach to causation.⁸⁴ Causation can be absorbed in a unitary analysis of subsidies and their effects or it can be separated out in a two-stage analysis that first assesses whether serious prejudice exists and then determines what causes it.⁸⁵ The panel in *US–Boeing* broke down the analysis further by first determining the intermediate effects of the subsidy on the recipient's technology, then determining the effects of those intermediate effects on the recipient's competitor's sales and prices, and finally evaluating whether those indirect effects of the subsidy on the market constituted serious prejudice.⁸⁶

The 'technology effects' analysis in *US–Boeing* is unlike any analysis in a prior GATT/WTO Panel Report because it treats developments in technology, rather than reductions in production and development costs, as the mechanism that transmits adverse effects. The 'learning effects' analysis in the *EC–Airbus* compliance proceeding resembles it.

These causal analyses have the merit of recognizing that firms compete more through technological advancement than lower prices in high technology markets.⁸⁷ Market actors do not carry out R&D for the sheer wonder of innovation but rather in the hope of improving output. Technology effects capture the competitive advantage conferred by innovation. They recognize that subsidies used for R&D can lead to a competitive advantage for domestic industries, but with higher risk and higher return than production subsidies. Attributing a mere financial benefit to successful R&D may greatly understate the true value of having a public body bear those risks. Technology effects recognize that subsidies for R&D can be much more efficient than other subsidies.

This interpretation of serious prejudice is influenced by the effects-oriented nature of the actionable subsidies disciplines.⁸⁸ Given that the effects of a given subsidy make that subsidy actionable, the choice of causal pathway may be wide open, insofar as the ordinary meanings of the terms used are broad enough to adapt to new factual situations as they arise. On this view, it does not matter how a recipient uses a subsidy, as long as that adversely affects the conditions of normal competition. Other countries will have a better chance to compete, including poorer countries that lack the resources to grant subsidies.

However, such an interpretation renders subsidies spent on R&D particularly vulnerable to challenge because relatively small subsidy amounts may cause relatively large adverse effects. For example, if a public agricultural research institute develops a new variety of seed that it sells at marginal production cost to farmers, the technology effect of the subsidy could be based on higher crop yield. If a government grants a tax deduction for R&D that ends up doubling the traveling range of an electric vehicle, the technology effect of the subsidy could be based on the vehicle's increased market share.

Such an interpretation also enables serious prejudice to be found even when a subsidized product is more expensive than a competitor product. Demand for a subsidized, innovative product can be driven by its superior features rather than its price.

This all exacerbates the problem that the SCM Agreement does not provide for any balancing of the possible positive and negative effects of subsidies.⁸⁹ The wide interpretation *does* take into account the positive externalities of technological innovation but, perversely, only as a measure of serious prejudice to a competitor. Moreover, it compounds the problem that the SCM Agreement,

⁸⁴The panel in *US–Boeing* referred to its degree of discretion twice before analysing the causal link on the basis of technology effects: see Panel Report, paras. 7.1656 and 7.1660.

⁸⁵Appellate Body Report, *EC–Airbus*, para. 1107. A unitary approach makes more sense when assessing adverse effects that inherently involve a counterfactual: see Appellate Body Report, *US–Upland Cotton* (Article 21.5), para. 354.

⁸⁶Panel Report, *US–Boeing*, para. 7.1660; Appellate Body Report, *US–Boeing*, para. 911 and fn 1856.

⁸⁷Panel Report, *US–Boeing*, paras. 7.1765–7.1769; Panel Report, *EC–Airbus* (Article 21.5 – US), para. 6.1220.

⁸⁸See Negotiating Group minutes (note 113 below), para. 7.

⁸⁹See Panel Report, *EC–Airbus*, para. 7.1991.

as it currently stands,⁹⁰ offers no way to take account of the fact that R&D subsidies can be an economically efficient response to market failure.⁹¹

The legal basis of the ‘technology effects’ causation analysis in *US–Boeing* appears to have been inferred from the panel’s discretion to choose a methodology. It was followed by the indirect ‘learning effects’ causation analysis in the *EC–Airbus* compliance proceeding. The panels’ respective findings reflect an interpretation of the actionable subsidies disciplines that can capture any type of competitive advantage in a given market. This makes R&D subsidies, or any subsidy used to fund innovation, more vulnerable to challenge.

3.2 Financial Effects on Production Costs and Prices Only

A narrower interpretation of the SCM Agreement may be appropriate, one that assumes that subsidies cause serious prejudice via their financial effects on costs of production and prices of the subsidized product. The definition of a subsidy, the nature of serious prejudice, the remedy to remove adverse effects, and the object of the SCM Agreement may all imply something regarding the causal link between a subsidy and its effects.

3.2.1 A Subsidy Must Be Financial

A subsidy is only covered by the SCM Agreement if it is financial in nature. Article 1.1(a)(1) provides that a subsidy usually involves a ‘financial contribution’ by government or a public body, which may take various forms. A financial contribution includes not only money, such as grants and loans (as in *EC–Airbus*) but also contributions worth money, such as goods or services or the purchase of goods, and even access to facilities, equipment, and employees (as in *US–Boeing*).⁹² Article 1.1(a)(2) provides that a subsidy may also involve income or price support, which are also financial in nature. It makes no difference whether a measure is supply-side or demand-side but it must be financial.

The determination of whether a subsidy exists requires a benefit analysis, which is also financial. Article 1.1(b) provides that a subsidy only exists where a ‘benefit’ is thereby conferred, the assessment of which usually involves a comparison with a market benchmark.⁹³ For example, in *US–Boeing*, the benefit of the R&D contracts, including the contractor’s access to government facilities, equipment, and employees, was assessed in financial terms through comparison with a market benchmark.⁹⁴

The definition of ‘subsidy’ does not mention the beneficiary or the subsidized product.⁹⁵ The definition uses the passive construction that ‘a benefit is thereby conferred’, which avoids any reference to the recipient or the way in which the recipient uses the financial contribution.⁹⁶ This definition also omits any reference to the product; hence, it is broad enough to cover a subsidy whether it operates directly or indirectly on the market. The definition does not address the way

⁹⁰The ‘green light’ categories in Part IV of the SCM Agreement, including Article 8.2(a) for certain R&D subsidies, expired at the end of 1999: see Article 31.

⁹¹Investment in R&D is inherently risky. R&D results consist of knowledge, which is non-rivalrous. The stimulus for private funding provided by the intellectual property system may prove inadequate where the resulting innovation leads to spill-over benefits for the productivity or research endeavours of other firms. As a result, the total welfare effect of an R&D subsidy can be positive: see Arrow (1962) at 617; WTO (2006) at 61.

⁹²The access was granted as part of collaborative undertakings akin to a joint venture: see Appellate Body Report, *US–Boeing*, paras. 621–625.

⁹³Appellate Body Report, *Canada – Measures Affecting the Export of Civilian Aircraft (Canada–Aircraft)*, WT/DS70/AB/R, para. 157. See also SCM Agreement, Article 14.

⁹⁴See note 22 above.

⁹⁵Article 2, on specificity, mentions the enterprises with access to a subsidy or that use a subsidy program.

⁹⁶Sykes (2003) at 20, noting that WTO law largely ignores the question whether the subsidy has an impact on the output of the beneficiary.

in which the effects of the subsidy reach the market, but it does require that the subsidy be financial.

3.2.2 *Serious Prejudice Must Be the Effect of the Subsidy at Issue*

Serious prejudice is one form of adverse effects to the interests of another WTO Member that can ground an actionable subsidy claim. The three forms of adverse effects set out in Article 5 are (a) injury to the complaining Member's domestic industry; (b) non-violation nullification or impairment, in particular of the benefits of tariff concessions made by the subsidizing Member; or (c) serious prejudice to the interests of the complaining Member. Most actionable subsidy claims allege (c), because serious prejudice can cover more than just the market of the complaining Member or the value of tariff concessions in the subsidizing Member.⁹⁷

Serious prejudice is defined in terms of market phenomena set out in Article 6.3, each of which is the effect of the subsidy at issue. These are (a) and (b) displacement of, or impediment to,⁹⁸ the complaining Member's exports (to the subsidizing Member or to a third country);⁹⁹ (c) significant price undercutting, price suppression, price depression, or lost sales (in any given market); and (d) increased world market share for a primary product or commodity. These phenomena are interrelated and can also be the effect of each other. Serious prejudice also includes a threat of any of these market phenomena that has not yet materialized.¹⁰⁰

3.2.3 *There Must Be a Causal Link between Serious Prejudice and Finance*

The SCM Agreement does not expressly address the nature of the causal link between a 'subsidy' in Article 1 and the 'effect of the subsidy' on a market and the interests of competitors in Article 6.3. It follows from the definition of a subsidy that the market phenomena must be the effect of a financial contribution (or income or price support). The financial contribution must affect output if it is to harm the interests of competitors.¹⁰¹ However, the Agreement does not state how the recipient uses the subsidy.

The financial effects of a subsidy can have an impact on output by lowering the cost of production. If the subsidy depends directly on output, it will reduce short-run marginal costs of production, to which recipients will generally respond by lowering prices of the subsidized product, which will lead to increased demand for the subsidized product.¹⁰² Alternatively, a subsidy may reduce long-run marginal costs of production, thereby maintaining or increasing productive capacity.¹⁰³ Either way, the financial effects of the subsidy under Article 1 can lead to increased sales or lower prices of the subsidized product, or both, and result in the market phenomena listed in Article 6.3.

Financial support is never a sufficient condition for innovation. R&D is risky and not simply a conduit between expenditure and results. Expenditure on R&D is only effective in assisting a

⁹⁷Countervailing measures, being unilateral, are usually the preferred remedy to address adverse effects in the market of a complaining Member. A total of 257 countervailing measures were notified to the WTO from 1995 to 2017, see www.wto.org/english/tratop_e/scm_e/CV_MeasuresByRepMem.pdf. Actionable subsidy claims have only covered a complaining Member's market as one among several geographical markets or as part of a global market.

⁹⁸'Impediment' is the noun derived from the verb 'impede' in this context, as indicated in Article 6.7. 'Impedance' refers to electrical resistance.

⁹⁹Displacement of, and impediment to, imports and exports are both forms of trade diversion. Impediment includes situations where, in the absence of the subsidy, sales would have increased more or declined less than they did: see SCM Agreement, Article 6.4; Appellate Body Report, *EC-Airbus (Article 21.5 – US)*, para. 5.680.

¹⁰⁰SCM Agreement, footnote 13.

¹⁰¹Sykes (2010) at 515. For this reason, the Agreement on Agriculture attempts to identify subsidies with no, or at most minimal, trade-distorting effects or effects on production: see Annex 2, para. 1.

¹⁰²See, for example, Panel Report, *EC-Airbus*, paras. 7.1963 and 7.1973; Panel Report, *US-Boeing*, para. 7.1806; Appellate Body Report, *US-Boeing*, para. 1171.

¹⁰³See Sykes (2005) regarding the effects of subsidies on producers at 87–88. Regarding the use of total or variable costs of production, see Appellate Body Report, *US-Upland Cotton*, para. 453.

recipient that is ready to pick up technological improvements, one who knows the next product that the market will need and buy.¹⁰⁴ The recipient's technical expertise may operate as the X factor that attenuates the causal link between the subsidy that financed the R&D activities and eventual increased market share or lower prices. The SCM Agreement does not provide redress for the unequal distribution of research capacity.

The context shows that the drafters of the SCM Agreement envisaged that a subsidy could affect the market through financial effects on production or prices. The quantitative threshold or types of subsidy formerly deemed to cause serious prejudice under Article 6.1 operated through financial effects on marginal costs of production.¹⁰⁵ The former 'green light' subsidy categories in Article 8.2 implied financial effects because they were based on the magnitude of the subsidy relative to costs, and the reimbursement of particular costs.¹⁰⁶ The other forms of adverse effects reach the market through the effects of subsidies on costs or price, or both: under Article 5 (a) injury is determined on the basis of the volume of subsidized imports and their effect on prices and the consequent impact on domestic producers¹⁰⁷ while under Article 5(b) non-violation nullification or impairment customarily protects the value of a tariff concession, which is 'to provide an assurance of better market access through improved price competition'.¹⁰⁸ The term 'serious prejudice to the interests of another Member' is used in the SCM Agreement in the same sense as in Article XVI:1 of GATT 1994,¹⁰⁹ which refers to the 'effect of the subsidization on the *quantity*' of the affected imports or exports (emphasis added).

Nothing in the context indicates that the drafters envisaged that a subsidy could affect the market through technology effects. In fact, the only reference in the Agreement to 'developments in technology' distinguishes them *from* the effects of subsidized imports.¹¹⁰

3.2.4 Adverse Effects Are Removable

One of the remedies in Part III of the SCM Agreement appears to assume that adverse effects are caused by financial means. Article 7.8 provides that the respondent either 'take appropriate steps to remove the adverse effects' or 'withdraw the subsidy', at the election of the respondent.¹¹¹ Given that the first of these remedies is effects-oriented, like the cause of action itself, it can shed light on how the grounds for a claim were conceived.

Removal of adverse effects, on the most straightforward reading, can entail reduction of payments.¹¹² Given that this remedy is an alternative to withdrawal of the subsidy, it indicates that

¹⁰⁴Lang (1997) at 721.

¹⁰⁵SCM Agreement, Article 6.1, listed total *ad valorem* rate of subsidization above a certain threshold, subsidies to cover operating losses, direct forgiveness of debt, and grants to cover debt repayment. It expired at the end of 1999: see Article 31.

¹⁰⁶The rationale for these limitations can also be seen as an attempt to distinguish R&D subsidies from production subsidies: see Stiglitz (1997) at 407. The terms of the limitations in the final version were drafted in part to protect particular US programs: see Doane (1995) at 170–171.

¹⁰⁷Panel Report, *EC–Airbus*, paras. 7.2055–7.2057, by reference to SCM Agreement, Article 15.

¹⁰⁸GATT Panel Report, *EEC–Oilseeds I*, L/6627, adopted 25 January 1990, para. 148. The SCM Agreement was negotiated contemporaneously with the *Oilseeds* dispute, which led to the follow-up report, *EEC–Oilseeds II*, DS28/R, 31 March 1992 (not adopted). The Chair of the negotiating group was also Chair of the panel. No adopted GATT or WTO Panel Report has ever found non-violation nullification or impairment of any benefit outside the context of a tariff concession or other individual commitment.

¹⁰⁹SCM Agreement, footnote 13.

¹¹⁰SCM Agreement, Article 15.5, regarding the non-attribution requirement for countervailing measures. Panels in actionable subsidies cases also distinguish developments in technology from the effects of subsidies. For example, boll weevil eradication and genetically modified cotton were raised as 'other factors' in Panel Report, *US–Upland Cotton*, para. 7.1362; and technological improvements in shipbuilding were raised as an 'other factor' in Panel Report, *Korea–Commercial Vessels*, para. 7.651.

¹¹¹Further, in cases of non-compliance, Article 7.9 provides for countermeasures 'commensurate with the degree and nature of the adverse effects'.

¹¹²The remedy is general enough to admit other means of implementation, such as the adoption of a separate measure to alter the benefit of the subsidy or to offset its adverse effects.

adverse effects can be removed without completely terminating a financial contribution or its benefit. This would occur when the amount of subsidy were reduced to a level where it did not cause increased sales or significant price effects within the terms of Article 6.3.¹¹³ Similarly, Article XVI:1 of GATT 1994 refers to the possibility of ‘limiting’ the subsidization that causes serious prejudice.

The reduction of payments can remove adverse effects but that assumes that the amount of the subsidy is related to the magnitude of its effects, i.e. that less subsidy leads to less effects. The amount of a subsidy will be proportional to its financial effects on marginal costs of production and, hence, to changes in market share, insofar as competition is based on price.¹¹⁴ In price-based competition, a competitor seeks to whittle away at an incumbent’s market share at a given point in time through price reductions. However, the amount of a subsidy does not correlate to its effects on technology or to changes in market share where competition is based on innovation.¹¹⁵ In high technology markets, a competitor may seek to supplant an incumbent entirely over time through innovations, until it is displaced in turn by the next wave of product advancements.¹¹⁶ For example, Blackberry’s once-dominant platform was entirely supplanted by Android and iOS because of functionality, not price.

The remedy of removal of adverse effects is also drafted in a way that assumes that the adverse effects can be removed or reversed through appropriate steps taken by the respondent government. That is a valid assumption where serious prejudice is caused by financial effects in a market insofar as competition is based on price, as in a commodity market. A limitation or withdrawal of the subsidy can reduce or eliminate its price effects, allowing prices to rebound, and market shares to revert to the *status quo ante*. That was the assumption underlying the grant of this remedy in *US–Upland Cotton* and one with which the drafters of the SCM Agreement were familiar, after the GATT complaints regarding subsidies for wheat, flour, and sugar.¹¹⁷ However, when serious prejudice is caused by technology effects in a market in which competition is based on innovation, a limitation or withdrawal of an R&D subsidy will not lead to a change in market share. Changes *ex post* to an R&D subsidy do not reverse the technological inferiority of a competitor’s product.¹¹⁸ The price of that product will not rebound nor will the competitor recover market share until it, too, introduces an innovation. For example, Airbus’ eventual competitive response to the 787 was to design the A350XWB.

Further, the remedy cannot require the respondent government to reduce payments by more than the amount of the subsidy, no matter how extensive the adverse effects are. The effects of a subsidy can be magnified beyond their cash value by factors including the nature of the subsidy (such as whether it is tied to production or prices), the dynamics of competition (such as the elasticities of demand and supply), and how the subsidy is applied.¹¹⁹ No provision formally

¹¹³During the negotiation of the SCM Agreement, some delegations expressly referred to the ‘elimination or reduction of the subsidy’ as means to redress adverse effects: see minutes of Uruguay Round Negotiating Group on Subsidies and Countervailing Measures, Meeting of 20–21 February 1990, MTN.GNG/NG10/16, para. 8.

¹¹⁴This does not imply that a panel is required to determine the difference in marginal cost of production due to a subsidy. However, an implementing Member would need to make an estimate so as to know by how much to reduce payments to remove the adverse effects.

¹¹⁵Lang (1997) at 721.

¹¹⁶Shelanski and Sidak (2001) at 12; Shelanski (2013) at 1669, citing Joseph A. Schumpeter, *Capitalism, Socialism and Democracy* (Harper & Brothers, 1942).

¹¹⁷See note 123 below. See also the report to the GATT Council on Article XVI:1 Discussions in *European Communities–Refunds on Exports of Sugar*, L/5113, 20 February 1981.

¹¹⁸Dissemination of the results does not remove a first-mover’s advantage, according to Panel Report, *US–Boeing*, para. 7.1771.

¹¹⁹Appellate Body Report, *US–Upland Cotton*, para. 461. For an example where the amount of the subsidy was too small to cause serious prejudice, see Panel Report, *Korea–Commercial Vessels*, paras. 7.682, 7.687, and 7.692.

limits adverse effects to the amount of the subsidy¹²⁰ but a respondent always has the option to withdraw the subsidy instead, which is inherently limited to the subsidy found to exist.¹²¹

3.2.5 Improvement of GATT Disciplines

The main object of the SCM Agreement, taken as a whole, is to increase and improve GATT disciplines relating to the use of both subsidies and countervailing measures.¹²² Subsidies claims under the GATT disciplines only ever alleged that the effects of subsidies were financial.¹²³ At the time of conclusion of the SCM Agreement, academic literature recognized that subsidies could confer 'learning curve' advantages but it analysed those effects on the basis of their impact on costs.¹²⁴ The 1992 bilateral agreement on aircraft between the US and EEC contained only a hint that the benefits resulting from technology obtained through government-funded R&D could be calculated in terms other than the reduction in particular costs.¹²⁵ Nothing indicates that a more expansive interpretation of the effects of government financial contributions on sales, prices, and market share was one of the intended improvements upon GATT disciplines.

In summary, the SCM Agreement provides that serious prejudice must be the effect of the subsidy at issue, which must be financial in nature. Although the Agreement does not explain *how* the subsidy causes serious prejudice, it may be a reasonable assumption that the subsidy operates through its financial effects on the cost of production and price of the subsidized product. This reading is supported by the remedy of removal of adverse effects, which impliedly assumes that those effects are proportional to the amount of the subsidy and expressly assumes that they can be removed by government intervention.

Subsidies for R&D do have financial effects but these can be distinguished from any technology and learning effects that they may also have. Subsidies for R&D reduce the recipient's costs, like any subsidy. A narrow interpretation would capture these effects. The results of subsidized R&D can also reduce the cost of production processes and create a price advantage, where competition is based on price,¹²⁶ but that may be considered the effect of the subsidy recipient's technical expertise. However, the technological effects of R&D do not necessarily lower the cost of production and, even when they do, that may not constitute their competitive advantage. New or significantly improved products can have the same or a higher cost of production but still increase sales for

¹²⁰Given that the remedies for actionable subsidies in Part III of the SCM Agreement are not additional import duties, there is no provision like Article 19.4, on countervailing duties.

¹²¹As to whether there is ever an obligation to repay a subsidy, see Moulis and O'Donnell (2000); Horlick and Clarke (2016) at 19.

¹²²Appellate Body Report, *United States – Countervailing Duties on Certain Corrosion-Resistant Carbon Steel Flat Products from Germany*, WT/DS213/AB/R, para. 73; citing the Ministerial Declaration on the Uruguay Round, MIN.DEC (the Punta del Este Declaration) p.7.

¹²³GATT Panel Report, *France–Wheat Exports*, L/924, adopted 21 November 1958, paras. 18, 23–25; GATT working party report, *US–Unmanufactured Tobacco Subsidy*, L/2925, 20 November 1967, (not adopted) para. 9; *Belgium–Income Tax*, L/4424, adopted 8 December 1981, para. 39 (and analogous paragraphs in the other tax legislation cases); GATT Panel Report, *EC–Sugar Exports (Australia)*, L/4833, adopted 6 November 1979, para. V(g); GATT Panel Report, *EC–Sugar Exports (Brazil)*, L/5011, adopted 10 November 1980, para. V(f); Subsidies Code Panel Report, *EEC–Wheat Flour Subsidies*, SCM/42, 21 March 1983 (not adopted).

¹²⁴See, for example, '[t]he curve that relates unit costs to accumulated volume is called the learning curve': Spence (1981). See also Barton (1983); Baldwin and Krugman (1988); Klepper (1994) and the literature cited by the original panel in *EC–Airbus* (at note 48 above).

¹²⁵The agreement provided that such benefits shall 'normally' be calculated in terms of the reduction in the cost of R&D and in the reduction in the cost of the production equipment or production process technology: see Agreement between the Government of the United States of America and the European Economic Community Concerning the Application of the GATT Agreement on Trade in Civil Aircraft on Trade in Large Civil Aircraft, signed at Washington and Brussels, on 17 July 1992, Article 5.3, 4th paragraph.

¹²⁶Subsidized R&D activities that lead to more efficient manufacturing processes, in particular, can allow producers to pass on manufacturing cost savings through lower prices and obtain increased demand in price-sensitive markets: see Spencer and Brander (1983) at 1.

reasons of performance or quality, to which competitors (not the subsidy recipient) will generally respond by lowering prices of the superseded, competitive product (not the subsidized product).¹²⁷ When competition in a market is essentially based on innovation, serious prejudice can be caused by the better product itself. A narrow interpretation would exclude these effects.

Accordingly, on a narrow interpretation, actionable subsidies claims would still lie against subsidies used for R&D unless and until a new green light category is agreed. However, the causation analysis of serious prejudice would be limited to the financial effects of those subsidies and not take into consideration technology or learning effects.

4. Remedies in Dynamic Markets

High technology markets may be too dynamic for the WTO actionable subsidies disciplines to provide a positive solution, even on a wide interpretation of the way in which serious prejudice may be caused. WTO remedies are prospective. This is an important limitation in any case but particularly when the effects of a subsidy are framed in temporal terms, such as Boeing's and Airbus' respective abilities to bring models of aircraft to market as and when they did. The problem is compounded by the duration of the dispute settlement procedures before a remedy is granted. Long product development cycles in high technology industries may mean that R&D subsidies have expired before any compliance obligation arises.

WTO dispute settlement proceedings take considerable time. Despite the many timeframes stipulated in the Dispute Settlement Understanding (DSU) (not all of them maximum periods), it is reasonable to expect even a typical dispute to take at least three years from consultations to compliance, and longer where compliance is disputed.¹²⁸ Serious prejudice cases take longer than average because they involve detailed economic evidence. Technology effects, if argued, require technical evidence and an assessment of the impact of innovative products or processes on competition.

The elements of the competitive environment on which a panel bases its assessment of serious prejudice in a high technology market are likely to be outdated before that assessment is complete.¹²⁹ For example, the 2004 complaint in *EC–Airbus* was largely motivated by Boeing's concerns about the amount of launch aid committed for the A380 but, by 2007, the United States was arguing that Airbus' decision to focus resources on that aircraft was an 'other factor' that caused Airbus' own problems.¹³⁰ Although market shares and prices in commodity markets also change during a WTO dispute according to supply and demand, the product being traded remains constant.¹³¹

If and when WTO remedies are granted, they are generally understood to be prospective only.¹³² The DSB lacks retrospective remedies, such as an account of profits for the period when a competitor did not have access to an innovation, and interim remedies, such as preliminary injunctions to restrain use of a product while a case is being heard.¹³³ It also lacks the powers of a competition authority to impose fines or order divestiture.

¹²⁷Cf. note 102 above and accompanying text.

¹²⁸See, for example, the DSB Overview of the state of play of WTO disputes, Annual Report (2014) – Addendum, WT/DSB/64/Add.1.

¹²⁹As regards this phenomenon in anti-trust investigations, see Shelanski (2013) at 1670–1672.

¹³⁰USTR press release, 'US Files WTO Case Against EU Over Unfair Airbus Subsidies', 6 October 2004; cf. Panel Report, *US–Boeing*, para. 4.352.

¹³¹For example, the price of cotton increased continuously throughout the WTO dispute in *US–Upland Cotton*.

¹³²Appellate Body Report, *EC–Airbus (Article 21.5 – US)*, paras. 5.374–5.375; cf. Panel Report, *Australia–Automotive Leather II (Article 21.5)*, WT/DS126/RW, para 6.20. See Horlick and Clarke (2016) at 19. Nevertheless, outstanding deliveries of orders already placed by customers might constitute continuing adverse effects: see Appellate Body Report, *US–Boeing (Article 21.5)*, paras. 5.333–5.336 and 5.344.

¹³³Cf. remedies based on the 'springboard' doctrine in certain common law jurisdictions, which can offset a head start in product development obtained through improper use of confidential information: see, for example, *Terrapin Limited v. Builders' Supply Company (Hayes) Ltd* (1967) RPC 375; *RLA Polymers Pty Ltd v. Nexus Adhesives Pty Ltd* [2011] FCA 423.

The speed of technological change is likely to render obsolete any remedy to remove adverse effects when those adverse effects derive from a time-to-market advantage. Such an advantage arises when the technologies at issue could have come into existence without subsidized R&D and it is eroded when the results become available to rivals. For example, in *US–Boeing*, the effect of the subsidized R&D was described as the 787's developmental head start over the Airbus A350. It was never definitively established whether the head start referred to the launch date or first delivery date, or when the latter would have occurred without subsidies.¹³⁴ Thus, it is possible that the effects of the technologies on Airbus were removed without any steps having been taken by the respondent government before the original panel even finished its report in 2011.¹³⁵ As there is no clear conclusion that those effects had *not* worn off by the end of the implementation period in 2012, the technology effects causation analysis rendered the compliance proceeding pointless as regards the R&D subsidies at issue in the original proceeding.

The passage of time may render obsolete any remedy even when adverse effects derive from the very market presence of a product or a competitor. For example, in *EC–Airbus*, even if launch aid had enabled the creation and market presence of aircraft that would not otherwise exist, the Appellate Body decided that there is no obligation under Article 7.8 of the SCM Agreement to take any compliance measures where the subsidies at issue have expired, even if their adverse effects continue.¹³⁶ That decision, which unmoored the remedies from the ground of action, suggests that the Appellate Body balked at the ramifications of a DSB recommendation to remove adverse effects in these circumstances.

Threat cases can be initiated earlier in time but WTO dispute settlement procedures are still slow and these claims also raise error–cost risks. It is very difficult for any tribunal, especially a WTO panel, to predict future market shares where the product itself is complex and the technology changes. Further, retrospective analytics such as net present value models can underrate innovation in the form of new products (as opposed to improved versions of existing products) because they make market projections based on past trends. If a panel were to find, wrongly, that R&D subsidies threatened adverse effects, it could delay the introduction of an innovation. The risk of missing out on welfare-enhancing innovation may outweigh the benefit of protecting the interests of a competitor. False positives are more costly than false negatives because, where there is no enforcement, there is at least the corrective of market forces.¹³⁷

Even if a panel finds that subsidies have caused serious prejudice through technology effects, this may merely postpone the day of reckoning to the remedy stage, when a compliance panel examines whether the respondent government needs to take any steps to remove adverse effects or withdraw the subsidy. Nonetheless, this does not shield subsidies used to fund R&D from challenge and any eventual ineffectiveness of SCM remedies would only become apparent at the end of costly litigation.

5. Looking Ahead

The importance of R&D subsidies is likely to increase. Technological innovation is needed to address societal challenges such as climate change, health, and food security.¹³⁸ R&D subsidies

¹³⁴ Appellate Body Report, *US–Boeing* (Article 21.5), paras. 5.341 and 5.442.

¹³⁵ The respondent elected to withdraw the subsidy in *US–Boeing* by modifying the terms of NASA and DoD licences. The compliance panel found that this failed to eliminate the benefit and, hence, to withdraw the subsidy: Panel Report, *US–Boeing* (Article 21.5), para. 8.197.

¹³⁶ Appellate Body Report, *EC–Airbus* (Article 21.5–US), paras. 5.383 and 6.11.

¹³⁷ Regarding the error-cost approach in competition law enforcement, see Easterbrook (1984) at 10; Manne and Wright (2010).

¹³⁸ United Nations Sustainable Development Goal 9 and Target 9.5; Global Innovation Index 2017: Innovation Feeding the World (Cornell University, INSEAD and WIPO); Global Innovation Index 2018: Energizing the World with Innovation (Cornell University, INSEAD and WIPO); Maskus (2015) at 5.

can correct market failure¹³⁹ and there is an increasing interest in a reinvigorated form of industrial policy.¹⁴⁰ Although actionable subsidies claims are not common, it is prudent to expect more.¹⁴¹ There are several ways in which a technology or learning effects analysis could be avoided in future cases.

R&D subsidies are no longer exempt from actionable subsidies claims on any interpretation of the SCM Agreement, whether wide or narrow.¹⁴² An incentive to argue technology effects arises in a market where subsidized technology itself creates a greater competitive advantage than the savings on R&D costs. That incentive can be diminished where a price effects analysis reflects the risk inherent in R&D funding by including, in the calculation of the financial contribution, subsidies for failed research efforts.¹⁴³ Knowledge spillovers may also diminish the product development head start gained from subsidized R&D.

The ineffectiveness of the remedies creates a disincentive to bring such claims in certain circumstances. Technology effects offer no effective remedy when R&D subsidies only give the beneficiary a time-to-market advantage that is shorter than WTO dispute settlement procedures. The DSU recommendation in *US–Boeing* provided no relief with respect to subsidies that Boeing received over the period 1989–2006 through US government R&D programs, even though they were worth at least \$2.6 billion.¹⁴⁴ Further, *EC–Airbus* illustrates that the Appellate Body will refuse any remedy where the subsidies at issue have expired before the end of the implementation period, even where the adverse effects of those subsidies have not. A potential complainant may judge that action under these procedures would not be fruitful.

Where a complainant is not dissuaded from initiating a dispute, the facts of a future challenge to subsidies for R&D may be distinguishable from *US–Boeing* in one or more respects. The subsidies may not be specific. The innovative product may not be ‘like’ the competitor’s product due to its additional functionality.¹⁴⁵ A subsidized innovation may not, in fact, confer a competitive advantage.¹⁴⁶ A product feature may be based on unsubsidized R&D.¹⁴⁷

In any event, a future panel may decide that the rules and remedies in Part III of the SCM Agreement assume that a subsidy would cause serious prejudice through its financial effects and not through developments in technology. The panel could distinguish the large civil aircraft cases on the basis that both principal parties argued technology and learning effects and neither contested the underlying legal rationale.

The technology effects causal mechanism could also be addressed in eventual negotiations to reform the SCM Agreement. Members might expressly agree that technology and learning effects are not envisaged as the effects of a subsidy for the purposes of Part III. This would reduce the degree of exposure to challenge of R&D subsidies, and other subsidies used for R&D. These subsidies would still be actionable on the basis of their financial effects, like any other subsidy, unless and until a new category of non-actionable subsidies is agreed.

¹³⁹See note 91 above.

¹⁴⁰Aggarwal and Evenett (2010).

¹⁴¹See, for example, *Canada–Commercial Aircraft*, WT/DS522. See also concerns regarding subsidies in US Chamber of Commerce, ‘Made in China 2025: Global Ambitions Built on Local Protections’ (2017).

¹⁴²See note 90 above.

¹⁴³Subsidies for failed research efforts can be included if they contribute to the development of a successful technology: see Appellate Body Report, *US–Boeing*, para. 1010.

¹⁴⁴Panel Report, *US–Boeing*, para. 7.1109; Panel Report, *US–Boeing (Article 21.5)*, para. 11.8(b).

¹⁴⁵As defined in SCM Agreement, fn 46. For an example of a panel that took into account particular product features when determining whether a subsidized product was ‘like’ the products from the complaining parties, see Panel Report, *Indonesia–Autos*, paras. 14.184–14.191.

¹⁴⁶The advantages conferred by the 787 technologies over the previous generation of aircraft were not seriously contested in *US–Boeing*.

¹⁴⁷In *US–Boeing*, the parties’ arguments focused on whether the 787 technologies were based on unsubsidized R&D. See Panel Report, *US–Boeing*, paras. 7.1749–7.1750. In future cases, the facts might show that a valuable product feature was based on spillovers: see Griliches (1992).

6. Conclusion

A rationale has emerged in the WTO large civil aircraft cases making subsidies that fund technological innovation particularly vulnerable to challenge. In *US–Boeing*, the effects of most R&D subsidies were analysed not in financial terms but, rather, as R&D results that led to technologies used on the 787 Dreamliner. Meanwhile, in the *EC–Airbus* compliance proceeding, the effects of launch aid were analysed not only in financial terms but also as innovations developed on the A380 and later applied to the A350XWB. The legal basis for this development in WTO jurisprudence was not articulated.

There is a mismatch between the WTO actionable subsidy disciplines and innovation-based competition. A wide interpretation of the rules takes account of the fact that competition can be based on innovation but exacerbates the problem that the SCM Agreement does not provide for any balancing of the possible positive and negative effects of subsidies. Moreover, the large civil aircraft cases illustrate that serious prejudice stemming from a temporal advantage in product development can be eroded by the prospective nature of WTO remedies.

A narrower interpretation would find the rules and remedies in Part III of the SCM Agreement intended for an analysis of the financial effects of subsidies on production costs and prices. A panel in another dispute may reach a different conclusion from the large civil aircraft cases regarding the causal link between subsidies used for R&D and serious prejudice in a high technology market, either in its application to the facts or in the interpretation of the SCM Agreement. A potential complainant should in any case weigh up the likelihood of success on the merits against the prospects for effective relief.

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