



**Australian Government**  
**Productivity Commission**

# Vulnerable Supply Chains

## Productivity Commission Study Report *Executive Summary & Findings*

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The Productivity Commission is the Australian Government's independent research and advisory body on a range of economic, social and environmental issues affecting the welfare of Australians. Its role, expressed most simply, is to help governments make better policies, in the long term interest of the Australian community.

The Commission's independence is underpinned by an Act of Parliament. Its processes and outputs are open to public scrutiny and are driven by concern for the wellbeing of the community as a whole.

Further information on the Productivity Commission can be obtained from the Commission's website ([www.pc.gov.au](http://www.pc.gov.au)).

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The full report is available at [www.pc.gov.au](http://www.pc.gov.au)



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# Executive summary

Australia's supply chains proved generally resilient in response to the COVID-19 pandemic, unexpected trade restrictions, the devastating 2019-20 bushfires and 2021 floods in Eastern Australia. Nevertheless, these experiences have highlighted potential vulnerabilities in Australia's supply chains. The onset of COVID-19 saw immediate impacts on logistics and transport. A global surge in demand and panic buying of some essential goods, notably personal protective equipment, with export restrictions placed on such products by some governments, added a degree of urgency to the unfolding situation.

In this environment, understanding the nature of possible disruptions received relatively little attention, but it did prompt a host of views on Australia's degree of self-sufficiency and strident opinions on how best to manage the risks involved. The Economist Intelligence Unit, a research advisory service, projected global value chains may become shorter, less fragmented and more regional. Others were less equivocal. For example, Andrew Liveris, then special adviser to the National COVID-19 Commission, said that: 'Australia drank the free-trade juice and decided that off-shoring was OK. Well, that era is gone ... We've got to now realise we've got to really look at onshoring key capabilities'.

Regardless of the response, managing the risks of supply chain disruptions — whatever their origin — inescapably entails costs on businesses, consumers and governments. These costs vary substantially and depend on the choice of strategy — stockpiling, diversification of suppliers or markets, contingent contracting, developing domestic capability, or tolerating the residual risk, among others. They also depend on the state of preparedness of firms and governments.

The purpose of this study is to help further Australia's preparedness to deal with possible global disruptions to the supply of inputs (upstream risks) as well as global disruptions to markets for goods and services (downstream risks). The report considers the factors that make supply chains vulnerable, with a focus on the international linkages and dependencies from trade. Significantly, we have developed and piloted a framework for identifying those supply chains and products that are vulnerable to disruption and critical to the effective functioning of the economy, using trade and production data. We then explore risk management strategies for governments and businesses and provide policy guidance on the roles for government.

## Supply chains and risks

Supply chains are networks of firms participating in the process of transforming inputs into final products and delivering these to consumers. Improvements in technology and trade

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liberalisation have made it easier and cheaper to source goods and services from overseas and equally to export our products and services to other markets. This has brought benefits from specialisation and economies of scale. It has also made supply chains more complex — modern supply chains often rely on inputs from across the globe and can consist of thousands of firms. The Dell supply chain, for example, was estimated to consist of over 7000 suppliers in 2019.

This intricate web of economic interdependencies means that a supply chain is potentially exposed to the many types of shocks that can affect every business, both in Australia and overseas: geopolitical (for example, a trade war), environmental (a natural disaster), economic (a financial crisis), societal (a pandemic) and infrastructure-related (a cyberattack).

Firm-level exposure to these risks depends on the characteristics of supply chains. A lack of flexibility, such as a dependency on one firm for a critical input, geographic clustering when all firms in an industry are in one location, and lengthy supply chains increase firm-level upstream risk. Downstream risks also arise from lack of flexibility, such as choke points in the logistics network (for example, key ports), and geographic clustering (for example, relying on a limited number of markets). To manage their exposure, those businesses that are most vulnerable use sophisticated tools and strategies, determined by their appetite for these risks and the relative costs of managing them.

From a policy perspective, however, it is not whether one firm in the market might experience disruption, but rather the exposure to market-level risk that matters most. In other words, the biggest concern arises when the whole market for a product could be at risk of disruption. For example, there is a market-level supply chain for automobiles, which includes the global supply chains that produce all automobiles for sale in Australia. Similarly, Dell's supply chain is just one part of the market-level computer supply chain. Lack of flexibility and geographic clustering shape market-level risk.

At an economy-wide level, it does not matter which firm supplies a particular good or service. If the supply chain of only one of many firms producing similar products is disrupted, that business may bear a substantial cost, but the societal cost may be small if alternatives are available. In contrast, it may be costly to society if the entire system that supplies an essential product is disrupted. For example, one brand of amoxicillin (a widely used antibiotic) disappearing from pharmacy shelves would not be a problem; but the disappearance of all amoxicillin could be a serious problem.

## **A 'data-with-experts' framework to identify vulnerable supply chains**

The Commission has developed a framework to identify supply chains for goods and services that are vulnerable to disruptions *and* whose absence would jeopardise the functioning of the economy, national security and Australians' wellbeing.

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A novel feature of the framework is the development of a ‘data-with-experts’ approach (figure 1). It casts a wide net by first identifying those products that are vulnerable to supply chain disruptions using a data scan. Then it identifies which of these vulnerable products are used in essential industries. The final step relies on expert assessment to stress test the data-driven analysis and to determine, from among the vulnerable products used in essential industries, those which are critical (goods and services that cannot be substituted easily, or the production process cannot be adjusted in the short term to avoid their use).

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Figure 1      **The Commission’s analytical framework**



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The Commission’s method differs from the approach of relying exclusively on expert consultations to identify essential sectors and the key inputs that may be at risk. One of the strengths of first applying a data scan is that it is largely agnostic (a priori at least) on those products likely to be identified as vulnerable to disruption. This reduces the probability of

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missing a good or service that *is* vulnerable. However, imperfect classifications of goods in any given dataset may still create false negatives (missing a vulnerable product) or false positives (identifying a product as vulnerable when it is not). Closer inspection and expert judgment can be used to reduce the number of false positives and capture vulnerable products missed by the data scan.

The framework still relies on some judgement, notably in specifying the goods and services that are considered essential. For the Commission's application of the framework to imports, essential goods and services were narrowly defined as those that meet the basic needs of Australians. Basic needs are part of the output of numerous industries, including food, water, health, communications, energy, logistics, finance, and government. A broader view of essential was used in our analysis of exports, which includes any goods and services that provide significant income security to Australians. Another area of judgment and choice is the time frame of analysis for assessing the economic impacts of disruption. We have focused on severe short-term (six-month) supply chain disruptions, because in the long run there is greater capacity to adjust and adapt to shocks.

The framework can be adapted to look at different scenarios. For this study, we have applied the framework to upstream and downstream disruptions in our analysis of Australian exports, and to upstream disruptions in our analysis of imports. It is also a flexible tool, with the user able to modify the key underlying assumptions. Care is needed, however, to ensure the assumptions are realistic, sensible and defensible. Otherwise, the results will be questionable and compromise the credibility of the analysis and any policy inferences drawn from them.

## **Testing the framework with imports data**

The framework developed by the Commission was piloted with Australian and global trade data to assess the upstream vulnerability of supply chains to imports.

Australia imported 5950 different products in 2016-17 with a combined value of A\$272 billion, equivalent to around 16 per cent of gross national income. These imports came from over 200 sources, although the majority by value were from the five largest suppliers — China, the United States, Japan, Thailand and Germany. The main imports by value were motor vehicles and parts; electrical, optical and other specialised equipment; fuel; pharmaceuticals; and chemicals.

As a first step to operationalise the framework and identify which imported products are vulnerable, filters are applied to the trade data. The first filter ascertains whether Australia's imports are highly concentrated (assumed to be when the main supplier accounts for over 80 per cent of imports of a product). The second filter determines whether there are limited alternative suppliers that Australia could access in the event of a disruption (assumed to be when the main exporter accounts for over 50 per cent of global exports). The third filter determines whether Australia sourced its concentrated imports from the main global supplier in a concentrated market.



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The results of applying the first filter suggest that one-in-five products (1327 products worth A\$30 billion) imported by Australia is highly concentrated. However, the global trade data indicate that for many of these products alternative sources of supply exist and could be utilised should the need arise (filter 2). Once all three filters are applied, the result is that one-in-twenty Australian imports (292 products worth about A\$20 billion) are identified as originating from concentrated sources of global supply and, by this combination of criteria, might be vulnerable. Two-in-three of these vulnerable imports came from China.

The list of vulnerable imports arising from the broad-based data scan reveal many products that, while having high import concentrations, are unlikely to be critical — either directly or as an input into the production of essential goods and services — to the wellbeing of Australians. Examples of such products include festive decorations, sparkling wine, clothing items, and toys.

The second step in operationalising the framework involves identifying whether any vulnerable imports were used to produce essential goods and services. This involves linking trade and production data that relate to a group of essential industries. The essential industries are mainly service-producing industries that primarily use locally-sourced services in their production; vulnerable imports constitute a small fraction of all the value of inputs into essential goods and services. Further, fewer than half of all vulnerable imports are used in essential industries.

Taken together, the analysis offers suggestive — but not conclusive — evidence that many essential goods and services do not depend critically on vulnerable imported inputs. The main supply chain disruption risks that could be problematic arise from the reliance on concentrated imports of some basic chemicals, or some personal protective equipment. For example, the supplies of face shields, isolation gowns, polyethylene aprons, and surgical cloths that are predominantly used in health industries were found to be vulnerable.

A common theme in feedback on the interim report related to the exclusion of food from the analysis, given the six-month time frame used for considering supply chain disruptions. Many study participants viewed this as a significant shortcoming. For the final report, the Commission has examined how the results change when food is included. The changes are minimal, adding seven products to the list of vulnerable and essential products. One of the products is a chemical input; the other six are foods imported from a limited number of sources, including maple syrup from Canada, which is clearly not critical.

The Commission's results have limitations, mainly stemming from the lack of product detail in trade data and difficulties in linking trade and production data. This is where specialised expertise is vital in stress testing the data-led approach. Expert knowledge is also required to identify whether an import is technically critical in the sense that its absence would interrupt the supply of an essential good or service. The Commission's method for assessing supply chain risks is best seen as a tool that complements an approach that relies on expert consultation.

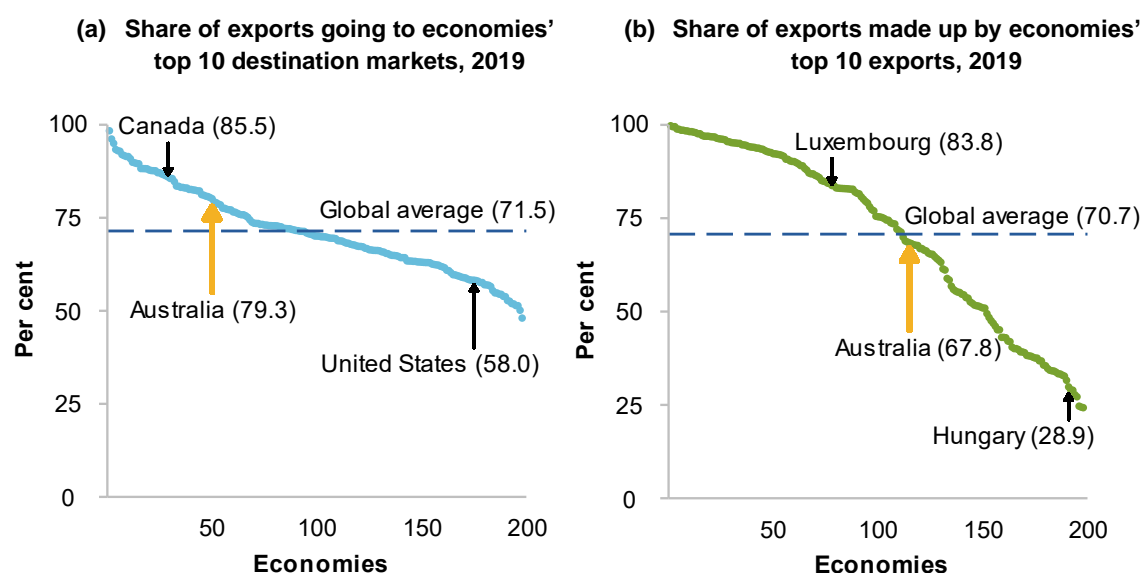
While not a substitute for expert knowledge, the Commission tested whether estimating demand elasticities for a selection of chemicals could corroborate the findings gleaned from the ‘data-with-experts’ approach. This can be informative, but data limitations made it difficult to apply the estimation approach systematically.

## Testing the framework with exports data

The framework was also applied to assess downstream and upstream risks to Australian exports. Whereas the analysis of imports took a narrow view of essential, focussing on risks to ‘life and limb’, the exports analysis adopts a broader view of essential to include any goods and services that provide a significant part of national income.

Australia is often misconstrued for having especially concentrated export markets, both in buyers and products, but in fact, Australia is not an outlier. In 2019, our top 10 destination markets accounted for 79.3 per cent of exports by value, while the global average was 71.5 per cent. And Australia’s top 10 exports accounted for 67.8 per cent of all of exports, slightly lower than the global average of 70.7 per cent (figure 2).

**Figure 2 The concentration of Australia’s exports by market and by product is close to the global average**



Data sources: CEPII (2021); OECD (2021).

As with imports data, filters were used to identify Australian exports’ downstream vulnerability. The filters chosen were designed to determine whether: Australia’s exports are highly geographically concentrated (filter 1); global trade is highly geographically concentrated (filter 2); and Australia’s main destination market is also the main global importer (filter 3).

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This analysis revealed Australia has limited exposure to downstream disruption to its exports, with only 35 products identified as vulnerable in most years recently (less than 1-in-100 of Australia's goods exports). Nearly 81 per cent of these products went to China. By value, however, these 35 products accounted for around one quarter of Australia's goods exports. Relaxing filter 1 from 80 to 70 per cent captures liquefied natural gas and increases the value of vulnerable exports to about one third of Australia's exports of goods and services.

Iron ore accounts for the big difference in export vulnerability as measured by number of products or by value of exports. On its own, iron ore accounted for nearly 95 per cent of the value of all vulnerable exports in 2019. It has been the largest source of Australian export revenue for the last decade; over 80 per cent has been exported to China in recent years, and China regularly accounts for over two thirds of global imports of iron ore. This makes both Australia and China vulnerable to disruptions in the iron ore market. It is equally a situation that lessens the risk of geopolitically-inspired disruptions, as the two economies have a vested interest in the efficient functioning of the market for iron ore.

The economic impact from a downstream disruption to Australia's exports depends on how quickly markets adjust, which in turn will depend on the nature of the product. For example, the experience following the recent restrictions placed on some Australian exports by the Chinese government has shown that products like coal (which is not identified as vulnerable) can quickly find new markets while others, such as rock lobsters (identified as vulnerable) have greater difficulty.

The difficulty that exporters face in expanding to alternative export markets is a function of many factors not fully captured in our analysis of global trade data. For instance, the costs of finding new customers will likely be smaller for standardised commodity products like coal than for differentiated products like wine (which require significant marketing and reputation development).

The framework was also applied to examine the extent to which the imports we identified as vulnerable are used in the production of Australia's exports. This analysis found Australia has limited exposure to upstream supply chain disruptions — our main export industries use only 66 of the 292 imports that were identified as vulnerable. Of these, the main risks arise from imports of chemicals used in mining.

## **How is risk managed and is there a role for government?**

Efficient supply chain risk management balances the trade-off between the costs of a disruption and the opportunity cost of investing in risk management. To make effective decisions on the level of action to take, firms need to understand the nature of the potential disruption (likelihood, size etc.), and its impact to their supply chains.

However, it is not straightforward to gather and assimilate the information needed to understand supply chains risks. Supply chains can be long, complex, and opaque, and data

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can be difficult to obtain. Biases can also affect the decisions of firms to invest in risk management. For example, because of their recent experience with the COVID-19 pandemic, firms may overinvest in strategies that seek to mitigate the risk of a pandemic, when other risks might be more probable and imminent.

Notwithstanding these challenges, risks are best managed by those who have direct incentives to mitigate them, and typically this means firms. Similarly, government has a responsibility to manage risks in supply chains for which they purchase and deliver goods and services directly. Key strategies used to prepare for supply chain risks include: accepting the residual risk (no action), stockpiling, supplier or market diversification, contingent contracting, and developing domestic capability. Several strategies are likely to be required to mitigate upstream risks.

There can also be circumstances where there is a rationale for government to intervene in market risk management. For example, intervention may be justified where risk management by a firm is hampered by regulation, or there is a divergence in risk appetite between firms and the community. A divergence could come about if, for instance, disruptions have spillover effects, or affect national security. In these cases, government could consider options ranging from providing information about risks that they are best informed about, to taking more direct ownership of risk management (such as supporting market diversification, maintaining government stockpiles, mandating or subsidising private stockpiles, or maintaining domestic production capacity).

That said, government intervention may crowd out private investment in risk management, imposing higher costs on the community. For example, the costs of maintaining local capability could outweigh the cost of other strategies. Further, onshoring could still rely on a critical input (such as crude oil), or Australia might lack the expertise to produce locally and be competitive. Onshoring may not reach efficient scale, particularly as firms often maintain several locations globally to diversify risks (and to control costs). Hence, even where an in-principle case for government intervention exists, any case for intervention needs to demonstrate that its benefits outweigh its costs.

One area where government could focus its efforts is on ensuring that firms do not face unnecessary constraints on how they plan for and respond to disruptions. A trusted and rules-based trading environment, for example, facilitates firms' ability to diversify their suppliers in preparation for, and their ability to find alternative suppliers in response to, a supply chain disruption. A responsive regulatory environment is another example.

Lastly, it is important that government periodically reviews and updates the list of goods and services that are vulnerable to supply disruptions and essential for the wellbeing of Australians, as it is likely to change over time. This role could be undertaken by the Office of Supply Chain Resilience, which the Australian Government established in 2021 to monitor vulnerabilities and coordinate whole-of-government responses to ensure access to essential goods.

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The frameworks developed in this study provide a means to repeat such reviews, and preferably reviews would include expert consultation. This approach is recommended to better understand where vulnerabilities will be visible in data and which data are best suited to identify vulnerable, essential, and critical goods — thus producing the information needed to understand risks and coordinate effective responses.



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# Findings

## Applying the framework to Australian imports

### FINDING 4.1: FEW IMPORTS ARE VULNERABLE TO CONCENTRATED SOURCES OF SUPPLY

One-in-five products imported by Australia are considered highly concentrated. Global trade data suggest that for many of these products alternative sources of supply exist and could be utilised should the need arise; one-in-twenty Australian imports might be vulnerable to concentrated sources of global supply.

### FINDING 4.2: MOST VULNERABLE IMPORTS ARE CONSUMPTION OR INTERMEDIATE GOODS

Although capital goods form the largest share of vulnerable imports by value, most vulnerable imports are consumption goods (such as personal protective equipment) or intermediate goods (such as sodium carbonate used in the treatment of water).

Disruptions to the supply of capital goods are unlikely to affect wellbeing in the short term.

### FINDING 4.3: THE MAIN SUPPLIER OF VULNERABLE IMPORTED PRODUCTS IS CHINA

China is the main supplier of about two thirds of the list of vulnerable imported products. Notwithstanding this, the main source of supply varies by product.

### FINDING 4.4: MANY IMPORTS CLASSIFIED AS VULNERABLE ARE NOT ESSENTIAL OR CRITICAL

Many imports classified as vulnerable are clearly not essential or critical to the wellbeing of Australians — for example, festive decorations, toys, or swimwear. Other vulnerable imports require further investigation to assess whether they are essential or critical.

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FINDING 4.5: VULNERABLE IMPORTS MAY NOT BE CRITICAL TO THE PRODUCTION OF ESSENTIAL GOODS AND SERVICES

The narrow definition of ‘essential’ used in this chapter comprises of mainly service industries. Locally-sourced services are the main input to their production, rather than locally-sourced or imported goods. Consequently, vulnerable imports are a small share in their production costs. This is suggestive evidence that vulnerable imports may not be *critical* to the production of essential goods and services, but is not conclusive because criticality can be independent of value.

FINDING 4.6: ESSENTIAL INDUSTRIES USED 130 VULNERABLE IMPORTS IN PRODUCTION

Essential industries used 130 vulnerable imports in production. However, many of the vulnerable products, such as textile products (excluding personal protective equipment), are unlikely to be *critical* to production in these essential industries. This suggests that the production of essentials is not highly susceptible to short-term disruptions to the supply of imported goods that come from concentrated sources.

The main supply chain risks lie in the use of vulnerable chemical imports in health (human medicine manufacturing), energy (petrol and coal product refining) and water treatment industries. Some of these chemical products may be critical.

FINDING 4.7: THE INCLUSION OF FOOD DOES NOT QUALITATIVELY CHANGE RESULTS

Including food as an essential good does not qualitatively change the finding that the production of essentials is not highly susceptible to short-term disruptions to the supply of imported goods that come from concentrated sources. Critical inputs of fertilisers and pesticides are not found to be vulnerable in this application of the Commission’s framework. But like other essential industries, the main supply chain risks to food production lie in the use of imported vulnerable chemical products and personal protective equipment.



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**FINDING 4.8: THE SUPPLY OF ESSENTIAL GOODS AND SERVICES IS NOT HIGHLY SUSCEPTIBLE TO DISRUPTIONS TO IMPORTED GOODS**

Combining imports and production data suggests that the supply of essential goods and services in Australia is not highly susceptible to a short-term upstream disruption to the supply of imported goods.

Vulnerable imports represent a small fraction of the value of essential goods and services consumed by Australians — whether that consumption be direct (final goods, A\$20 million out of total consumption of essential goods and services of A\$593 billion) or indirect (as inputs into Australian production, A\$2.7 billion). But this evidence is not conclusive and industry experts are required to determine criticality.

## **Applying the framework to Australian exports**

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**FINDING 5.1: DATA SUGGESTS THAT LESS THAN 1-IN-100 OF AUSTRALIAN EXPORTS ARE VULNERABLE DUE TO CONCENTRATED SOURCES OF GLOBAL DEMAND**

Nearly one-in-five of Australia's good exports is considered highly concentrated but global trade data suggests that many of these exports could find alternative markets if needed. The result is that less than 1-in-100 of Australian exports might be vulnerable to concentrated sources of global demand.

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**FINDING 5.2: AMONG AUSTRALIA'S MAIN GOODS EXPORTS, ONLY IRON ORE IS IDENTIFIED AS VULNERABLE**

Among Australia's main exports, data analysis identifies only iron ore as vulnerable. Including iron ore, vulnerable exports account for around 25 per cent of the value of goods exports. Excluding iron ore, only around 1.5 per cent is considered vulnerable (using the Commission's framework and thresholds).

Even for an export as valuable as iron ore, identification as vulnerable using the framework developed here has no immediate implication for public policy.

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**FINDING 5.3: AUSTRALIA'S BIGGEST SERVICES EXPORTS ARE NOT VULNERABLE**

Education and tourism services are Australia's biggest services exports. These services are not identified as vulnerable because the main importer makes up less than 40 per cent of the market. However, both education and tourism services are vulnerable to factors that impede the movement of people.

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FINDING 5.4: FEW IMPORTS IDENTIFIED AS VULNERABLE ARE LIKELY TO BE CRITICAL TO THE PRODUCTION OF AUSTRALIA'S MAIN EXPORT INDUSTRIES

Australia's main export industries used 66 vulnerable imports in production, but most of these products are unlikely to be *critical* to production processes. Further, vulnerable imports are a small share of the goods used in production, by value, which is suggestive evidence that they may not be critical to production, but it is not conclusive because criticality can be independent of value. Consultation with industry experts is needed to assess criticality, especially for vulnerable imports of chemical products used in mining.

## Supply chain risk management

FINDING 6.1: SUPPLY CHAIN RISK MANAGEMENT FRAMEWORK

Supply chain risk management is similar to buying insurance for other types of risk. In effect, a firm pays an insurance premium upfront to invest in strategies to insure itself against potentially large cost increases if a disruption occurs.

FINDING 6.2: UNDERSTANDING SUPPLY CHAIN RISKS

Effective risk management requires firms to invest in understanding their supply chain risks to ensure that the benefits of any investment to mitigate the costs of disruptions is at least matched by their potential effects and costs.

FINDING 6.3: HOW WELL STRATEGIES PERFORM DEPENDS ON THE TYPES OF DISRUPTIONS

Each risk management strategy has costs and, some will perform better under different types of disruptions and contexts. Firms will employ a range of strategies to effectively manage risk, such that the benefits exceed the costs.

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## The role of government in risk management

### FINDING 7.1: RESPONSIBILITY FOR MANAGING SUPPLY CHAIN RISKS

Risks are best managed by those who have direct incentives and the capacity to mitigate against them.

Firms are primarily responsible for managing risks in their supply chain. Governments have responsibility, like any firm, to manage risks in supply chains where they purchase and/or deliver goods and services directly, particularly when these are essential goods and services.

### FINDING 7.2: GOVERNMENT INTERVENTION IN PRIVATE SECTOR RISK MANAGEMENT

Government intervention in private sector risk management may be justified when society's tolerance for a residual risk is lower than the residual risk that results from the market and where government or other impediments prevent firms from effectively managing their risks. However, government intervention can crowd out private investment in risk management — the net benefit of any intervention should outweigh the costs.

All levels of government have responsibility for ensuring regulations are fit for purpose, including making temporary changes that let firms adjust to major disruptions. The Australian Government also has responsibility for maintaining and promoting a rules-based international trading system that is respected and kept up to date.