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Transforming Trash into Treasure Troves: SMEs Co-Create Industrial Ecology Ecosystems with Government

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Abstract: Industrial ecology addresses newer business models that improve flows of energy, water, and materials, mimicking interconnections found in natural systems. Businesses can function interdependently to extend the life cycle of resources by setting up systems to repurpose waste or transfer a byproduct of manufacturing as an input for creating another product. Although the extant literature focuses on the role of businesses in closed-loop processes, governments can catalyse sustainable entrepreneurship to transition to a circular economy. There is a limited understanding of how public–private partnerships can facilitate this shift in small and medium enterprises. Multiple case studies were conducted to examine industrial ecology projects that were spearheaded by a state grant scheme in Australia. The long-term progress in establishing initiatives across commercial and industrial projects was monitored. The findings show government incentives to start up projects facilitate conditions to develop technology and other capabilities for responsible production and consumption. This study extends the theory of innovation ecosystems into practice. The model demonstrates that sustainable value for business and society can be realized through financial support and collaboration that enables entrepreneurship and drives circularity across cities and regions.

Keywords: circular economy; ecosystems; industrial ecology; innovation

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1. Introduction

Although the availability of resources has brought a multitude of modern conveniences primarily to the developed world, it has conversely exacerbated environmental degradation and human rights infringements [1]. Moreover, traditional methods of production and consumption based on gross domestic product (GDP) are viewed as responsible for causing resource scarcity and an abundance of waste [2]. Radical reforms are needed to alter how resources are organized and capitalized to combat these problems. However, measures for greater resource productivity can counteract the effect of the 'make, use, and dispose' model. Under the closed-loop paradigm, resources are recovered, and alternative processes are adopted to regenerate products, components, or materials, resulting in a healthier environment from lower emissions and pollution and social benefits from higher quality employment [3]. Profit can also be realized by converting existing goods into new sources of entrepreneurship and capital [4].

There are several types of closed-loop industrial ecosystems. This paper will refer to the systems that replace virgin materials with renewable, recyclable, or biodegradable resources. Waste is converted into assets through the activation of circular business models [5] that compare to food and industrial webs [6] whereby byproducts of water, energy, and materials are exchanged with other businesses for sustainability and symbiosis [7,8]. Enterprises may conveniently set up cooperative ventures in one area to achieve economies of scale, including lower infrastructure costs. This kind of industrial ecosystem is exemplified by the technological precedent of Kalundborg Eco-Industrial Park (EIP) in Denmark [9].

Kalundborg EIP started in 1961 to conserve water resources using recycling and reuse functions for added value. Today, it houses more than 30 linked businesses, comprising a fish farm, fertilizer plant, cement company, refinery, wastewater treatment facility, power supplier, and municipality, among others. Firms are connected to transfer matter and avoid a drain on groundwater while optimizing energy efficiency [9]. More frequently, businesses establish one-to-one exchanges. These partnerships tend to be structurally less complex and analogous to a food web because they usually receive energy and/or materials rather than providing feedstock for industrial ecology (IE) or reusing their own matter for a secondary purpose [6].

Research on IE focuses on the role of businesses in stimulating the high-tech industry, but concurrently, it has been drumming up attention and action from national policy agendas. Implementing policies and offering public financial aid can complement private expenditures to drive positive change in countries such as China [10]. Government interventions can generate not only investment but market demand for a circular economy, heightening the desire for used products from original equipment manufacturers and independent remanufacturers, as businesses must comply with regulatory requirements imposed by governmental agencies.

Public–private partnerships can therefore drive business for IE. Doing so will reduce the use of virgin materials and help to enlarge systemic models, as demonstrated by technological practitioners engaged in advanced smart systems to capitalise on the added value presented by IE [11]. Such partnerships between government and enterprise could induce the restructuring of production patterns to foster ecosystems in IE.

This research investigated small and medium enterprises (SMEs) that received funding and networking opportunities from a state government grant program to establish IE initiatives. Two research questions were posed. First, how did the partnerships between government and SMEs in the IE program translate into processes and business models to achieve the objectives of each funded project? Second, what were the grantee experiences and triple bottom line effects of participating in the program?

This article opens with a literature review. Next, there is an explanation of the materials and methods used in this study. Empirical evidence follows to explain how the grants were operationalized by grantees. The results show the government scheme brought positive contributions to advance the circular economy by redirecting waste as a renewable resource to create products with longer life cycles, lower environmental impacts, and other benefits. Innovative business models introduced by the SMEs are then discussed and interpreted, demonstrating the value of instituting co-managed projects beyond frameworks to spur IE progress, which extends the theory on innovative ecosystems. Implications of the results of the partnership projects in facilitating new capabilities are displayed in a framework prior to considering areas for future research.

2. Literature Review

Stock [12] and Rogers and Tibben Lembke [13] proposed early concepts and practices of reverse engineering as an IE method. Next, it was popularised by the widespread publication of *Cradle to Cradle* [14]. This book contained the popular butterfly diagram seen in Figure 1 to convey the principle that technological networks can be designed to follow self-perpetuating processes [15]. As stated, businesses may be co-located to optimise the use of shared resources and to achieve mutual efficiencies in the reduced intake of virgin resources for production and lessened emissions for a lower environmental impact [16].

The efficacy of IE ecosystems also depends on concerted participation along the value chain by consumers to act as enablers through making changes in their purchasing habits and governmental support to instil conditions for significant impact. Governments can be stewards in promoting service design thinking and action to implement forms of systemic change for a circular economy. Indeed, many governments recognise this need because resource use is projected to continue to climb [17,18], and many nations depend on imports, which are likely to grow scarce. Heightened competition for resources has already led to volatile price swings and disruptions in supply [19].

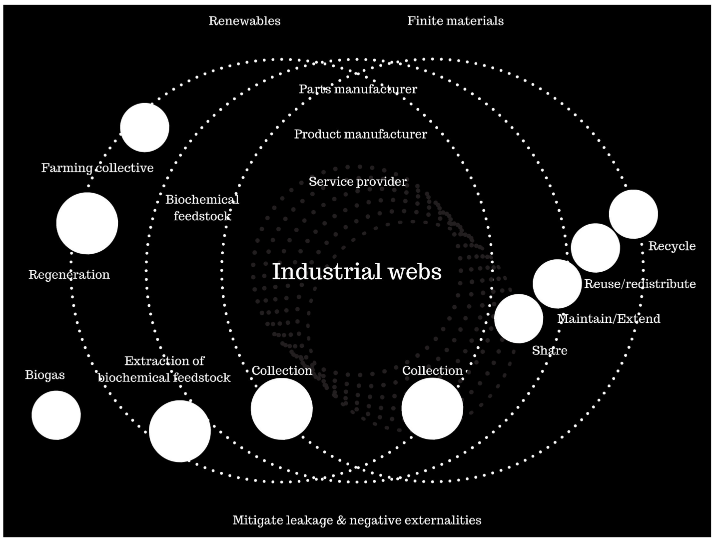

Figure 1. Industrial webs adapted from Ellen MacArthur Foundation [15].

The COVID-19 crisis forced an escalation in demand for products [20]. Constructing processes to conserve resources is not only practical, but policies are also crucial to deploy strategies that can utilize natural resources to harness greater energy efficiency [21] because that will help accelerate the transition to a circular economy.

Chen and Chen [22] proposed a framework for reverse logistics management between government and business to stimulate circularity (see Figure 2). They contend that creating market value for circular products in the same manner as traditional products is necessary, the most efficient way to build interest in it by consumers, and brings a competitive advantage for business. Government can play a leadership role by offering policies and programs to realize this outcome.

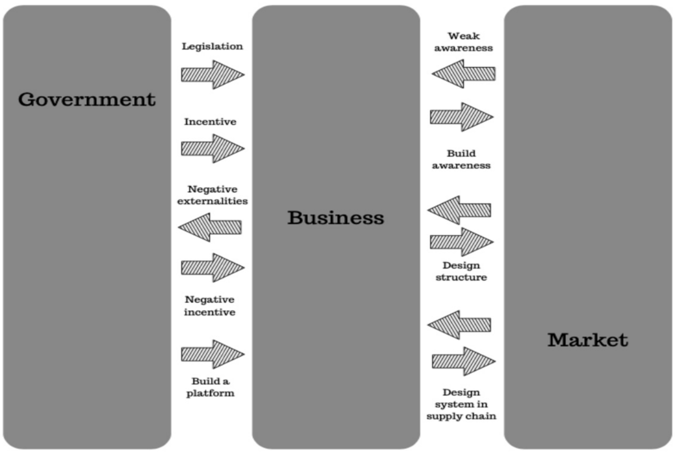

Figure 2. Framework to facilitate reverse logistics adapted from Chen and Chen [22].

Applying a combination of market and economic theories of government intervention [23] through offering incentives to establish new IE business models could act as a strong catalyst for investment. Early studies across countries that tested the waters by offering public subsidies for technological innovation found conflicting results. For instance, Wallsten [24] evaluated 81 cases from the United States and concluded that government subsidies did not encourage technological innovation, unlike Toivanen and Niininen [25] who looked at Finnish companies during 1989–1993 and determined public subsidies caused a 'substitution effect' by having the government provide subsidies to large enterprises for technological innovation. Conversely, Antonelli [26] evaluated 86 samples in Italy, which indicated a significant positive correlation between offering public subsidies and a rise in technological innovation.

A more recent study of China [27], which is transitioning to a market economy, demonstrated that government subsidies significantly increased investment in the research and development of technological innovation when introduced in conjunction with market reforms. The results confirm an earlier Chinese study [28]. Policymakers can thus be instrumental in allocating public resources for innovation that could be used to advance industrial ecology.

The European Union has alternatively shown global leadership in developing policies and regulations and disseminating information towards this end [29]. Although research from Europe reflects policy instruments may be available for SMEs to incorporate principles of circularity into their business models, barriers must be overcome to embed change. This can be achieved through creating dedicated closed-loop markets and building communities of practices [30].

Three stages to implement reverse engineering are suggested as ways public–private partnerships can bring optimal outcomes [22]. First, clear policies and regulations should be passed to elucidate the responsibilities and identify the actors that are needed to work together. Second, the government should offer incentives to position reverse logistics for acceptance within the marketplace through finding qualified businesses that can perform. Any tax relief that is offered could be recovered by the government by instituting a carbon tax whereby polluters or those businesses that are contributing negative externalities from their operations would incur penalties or charges to fund IE activities. Third, the government can encourage reverse logistics to gain a foothold in the market by connecting purchasers of byproducts or waste materials with remanufacturers or recyclers.

International Agendas to Close Industrial Loops

Although the European Commission's enacted Circular Economy Action Plan [29] aims to raise EU GDP by 0.5% and to create approximately 700,000 new jobs by 2030, it relies on member states and specific regions to adopt their own regional or national policies and implement concrete measures for new business model creation. Despite the potential positive impacts, thus far, this key governance framework suffered setbacks in translating theory into practice [31].

China had similar experiences after adopting a Circular Economy Promotion Law [32] to curb excessive waste and bolster global competitiveness while it is making shifts towards recycling and renewable energy. There is an apparent dislocation in the relationship between government and business that requires governed interdependence [33]. Giving clear government directives with adequate capital investment could bring a turnaround when private income stops treating IE as a cost or externality.

Australia has also taken a larger stance on resource recovery since the Commonwealth Government introduced a National Waste Policy [34] to improve recycling. Pre-disposal resource recovery has been driving better practices. Several jurisdictions have mandated source separation for recycling prior to granting approval to landfill facilities [35]. Although an estimated 806 resource recovery facilities operate to sort recyclables, they vary according to the types and volume of the discarded materials that can be sorted and processed via mechanical, thermal, or biological technologies. Differences are also seen across states that have adopted individual policies and programs to foster waste solutions.

This study focused on an IE program that was offered by the New South Wales (NSW) Environmental Protection Agency (EPA) primarily within metropolitan Sydney and its outlying regional areas. New opportunities were afforded by a grant scheme called Circulate that was set up for SMEs to get involved in commercial and industrial (C&I), and specific construction and demolition (C&D) IE projects over six years with costs offset by a state levy on landfill waste [36].

The government program was one of a host of grants that were disbursed to businesses under NSW's Waste Less, Recycle More initiatives to divert materials from landfills for repurposing [37]. C&D materials alone in 2018–19 accounted for 27.0 Mt or 44 per cent of all waste generated in Australia [38]. And globally, waste generated from commercial, industrial, and construction is huge. It accounts for between five and eight billion tons per year, excluding mining and carrying [2]. Further, the construction sector accounted for over 34 per cent of energy demand and around 37 per cent of energy and process-related CO_2 emissions in 2021 [39]. Despite the increase in energy efficiency investment and the lower energy intensity, energy consumption, and CO_2 emissions that were documented during COVID-19, rates in construction have now rebounded to an all-time high [40], underscoring the significance of addressing these negative impacts.

The research applied the lens of innovation ecosystems theory to interpret the findings of the SMEs that derived funding from the NSW EPA to launch their IE projects. This framework relates to the interdependencies among the actors in which firms jointly develop a coherent and customer-centric approach to capture value. It is applicable in this context where the cases come from a range of industries, and no uniform standards or approaches are taken to create IE among interconnected actors [41].

3. Materials and Methods

Multiple case studies were conducted to gather data from the grant recipients. This type of methodology is ideal for conducting phenomenological research [42] because it allows multiple realities to be synthesised to construct an accurate picture of events. A researcher studies multiple cases to grasp similarities and differences between the cases that highlight important influences of what is portrayed. It allows for 'theoretical evolution' and wider discovery to answer the research questions [43]—in this context, to understand the creation of IE ecosystems and effects of the projects.

Semi-structured interviews were held for one hour with founders or managers from six cross-sector industry companies that received funding between July 2020 and March 2021. The questions covered reprocessing waste, economic, social, and environmental impacts of individual projects, the grant scheme process, and the circular business models that were pursued by the organizations. Operations for these businesses were then tracked until their funding period finished at the end of 2022 due to COVID-19-related extensions and to be confident the projects were delivered as intended.

Table 1 explains background information that was collected about the grantees and details of their projects.

Table 1. Grantees and Project Descriptions.

Companies and Partners	Classification	General Operations	Project Aim and Funding Amount	Staff Number
Centre for Organic Research and Education (CORE)	R&D in waste management	Tests and analyses crushed organic resources in biofilters to install circular infrastructure systems	To develop methods to substitute sand to manufacture biofiltration technology for runoff water treatment using organics, timber, and mixed cullet glass fines—97,500 AUD *.	5
Circular Centre Pty Ltd.	Sustainable textile supplier	Wholesales eco-friendly textiles and cooperates with disability businesses to extract fibres for repurposing	To capture, sort, dismantle, and repurpose denim and other textiles for redesign and remanufacture—150,000 AUD.	3
Good360 Australia Pty Ltd.	Not-for-profit	Distributes new goods that companies donate to those in need	To recover unsold, nonperishable personal care items from storage for redistribution to refuges and shelters—148,446 AUD.	30

Table 1. *Cont.*

Companies and Partners	Classification	General Operations	Project Aim and Funding Amount	Staff Number
Stephen Mitchell Associates (SMA)	Environmental consultant	Sets up forest stewardship and responsible wood chain of custody certifications and timber resource recovery	To replace hardwood timbers by targeting timber recyclers, wood manufacturers, importers, and logistics companies to reuse or recycle offcuts, pallets, and crates—143,225 AUD.	1
Wild Blue Global Consulting	Environmental consultant	Connects suppliers of resources with repurposers	To recycle rockwool growing medium and plastic packaging from the hydroponics industry. To collect and reprocess timber from pallets for making animal bedding. To trial education for diverting organic food waste and to recover and reuse metals, plastics, timber, and organics from manufacturing, mining, and agricultural sites—636,920 AUD.	3
Yume Food	Social enterprise	Wholesales surplus food	To extend the organisation's online marketplace, connecting suppliers of surplus food with buyers—100,000 AUD.	10

* AUD is Australian dollars.

To be eligible for funding, the organizations needed to rely on financial assistance to start up the initiatives that relate to business-to-business transfers of materials that would curb the largest waste streams from C&I and C&D sectors. The EPA imposed other criteria to qualify for compensation, including the projects having to divert at least the benchmarked tons of waste per material listed in Table 2.

Table 2. Tons of Materials to be Recovered [37].

Materials	Minimum Tons Diverted
Glass	100
Metals	400
Organics	80
Hard/rigid plastics	80
Soft/flexible/polystyrene plastics	20
Textiles	20
Timber	400

Once the grantees demonstrated performance through their reporting at project milestones, the EPA reimbursed them. Current market rates per material were used to determine the funding that was disbursed as seen in Table 3.

The steps for carrying out the research process began with primary and secondary data collection to capture the diverse views of stakeholders. Interviewees were issued copies of their transcripts for verification, and the findings were triangulated. More than 200 documents, including company websites of the grantees, reports and journal articles from Scopus, and wider business databases, were reviewed. Assembling data from multiple sources allowed confirmation of inferences through a recursive research design [44] on the IE ecosystems that grantees were developing. Next, preliminary analysis led to thematic coding. When data saturation was reached, higher-level evaluation ensued to ensure rigorous results were achieved. The research path is illustrated in Figure 3.

Table 3. Guide to Assessing Project Funding [37].

Type of Material	Minimum AUD/Ton Waste	Maximum AUD/Ton Waste
Glass	40	200
Metals	10	50
Organics	70	250
Hard/rigid plastics	70	250
Soft/flexible/polystyrene plastics	300	1000
Textiles	200	1000
Timber	25	50

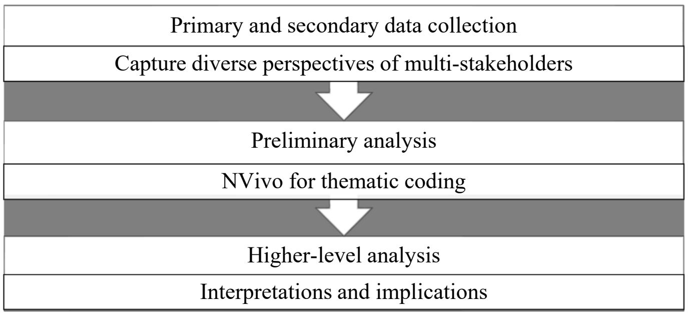

Figure 3. The research path for carrying out multiple case studies.

4. Results

The evidence reveals that each grantee took a bespoke approach to embracing IE through recovering remnants, offcuts, packaging, unwanted goods, and waste byproducts. What follows is a description of the key themes portrayed in Figure 4, beginning with an explanation of the IE processes that the companies employed.

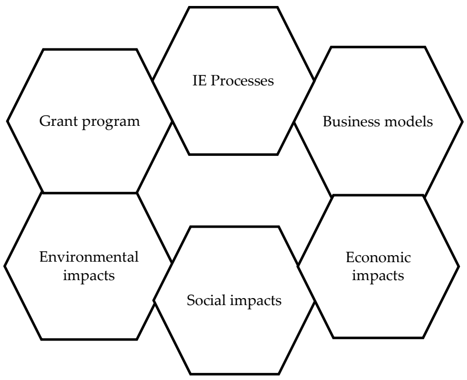

Figure 4. Themes studied on emergence of IE ecosystems.

4.1. Unique Processes and Business Models

CORE supplies research for commercialization through multi-stakeholder partnerships. For Circulate, they collaborated with a university and several resource recovery companies to develop methods to substitute sand in manufacturing biofiltration technology for the benefit of local councils. The outputs were computerised systems that revealed how organics, wood, timber, and mixed cullet glass fines could be recycled in biofilters to treat urban, industrial, agricultural, mining, or stormwater runoff while protecting waterways.

> *A lot of unprocessed wood and timber is mulched into fine particles. We engineered it to be a component of media, a bit like a potting media, except that it filters water . . . Food*

waste is linked to having high levels of nitrogen. It can be used in the early stages of processing wood and timber and garden vegetation, and it can be used in combination to break those materials down.

(CORE respondent)

CORE characterizes what levels of those materials will yield optimal components in a biofilter to best treat the pollutant profile of a given site. Garden vegetation might make up 20 to 30 per cent. Timber might comprise between 30 and 40 per cent of the total composition. Their biofilters meet industry standards and are superior to sand filters that only present a one-size-fits-all approach. The filters cannot treat every contaminant though, so plants are usually added to attack even more pollutants while providing good growth media to enhance the water quality of their treatment systems.

It also makes fiscal sense for councils to convert to CORE's biofilters. Sand is being depleted in many areas, which makes it costlier to source from faraway locations, and many councils have available supplies of organic materials. They collect organic waste in bins or at drop-off centres, which may be recycled into compost. Putting that kind of waste into biofilters gives a higher value than selling it as compost. Wholesale prices can reach 150 AUD compared to 30 AUD per cubic metre tray of compost. There are minimal additional expenses to prepare the material for a biofilter.

Circular Centre is a commercial textile enterprise. They were funded to take back unwanted wearables deposited at community collection sites in Sydney. The clothes are separated or forwarded to a disability enterprise where returned garments move along a conveyor belt to be sorted into 120-kilo loads of various waste streams. A robotic arm was being developed for installation on a machine to expedite deconstruction.

It will operate like a gantry system for the arm to be able to read a shirt, press it down, and then clip off a button. We ran some tests to see how long it takes man versus machine. It took the workers 57 s, whereas it takes the robot gun seven seconds.

(Circular Centre respondent)

Another program encourages corporations, designers, and students to participate in redesigning used denim. Circular Centre captures this material for reuse in Australia rather than sending it overseas, which becomes a problem elsewhere. Also, the company sells eco-friendly fabrics while it introduces innovations in textile reprocessing.

General Pants backed that idea with us . . . They collected 500 recycled pieces through their Denim Amnesty program . . . I chose denim as the fabric to isolate, particularly since it is a high-resource product. We'll be putting jeans back into the circular economy and calculating the savings of emissions along the way.

(Circular Centre respondent)

Wild Blue Consulting conducted a range of pilot projects, such as instigating a circular food waste initiative, Plate to Paddock, within its local community. They helped REMONDIS, a waste management company, to raise awareness about diverting excess wood pallets and plastic to new end markets instead of landfills by hosting breakfast meetings for approximately 200 businesses.

After developing relationships and building trust with stakeholders for their consulting business, Wild Blue began to act as a broker to divert wood for reprocessing by connecting generators of wood waste with recyclers. When oil prices rose, making virgin plastics less competitive, they turned their attention to diverting plastics for reprocessing. These activities yielded approximately 45,000 AUD in annual savings, which continue to generate profit.

Some facilities were shredding wood waste and sending it overseas in huge bales . . . Apart from natural timber that can be composted and is resold here, companies could only put in five per cent as part of the shredded material for animal bedding and stuff like that. Large-scale engineered timber, however, had to go down to Benalla [for particleboard]

. . . Now we've gotten closer facilities that have opened for wood waste here in New South Wales.

(Wild Blue Consulting respondent)

SMA also acted as a broker for wood waste. Their personnel are wood experts who know the regulations and strive for quality and reliability in reprocessing wood over converting it into low-grade mulch.

They've got to sample and test their wood products for metals and contamination—whether it be plastic or glass or chemical contamination because wood can be treated with different preservatives. Or the wood could have resins in it which the EPA says aren't acceptable. . .The companies I work with do sampling and testing to make sure that they're not selling a bodgie product.

(SMA respondent)

Drawing from industry contacts, SMA dealt with companies whose staff can distinguish precisely what material is suitable for recycling, for example, frame and truss manufacturers who have smaller offcuts of wood or glass importers who collect large crates from packaging. SMA connected them with suppliers who could reuse pallets in good condition, chip them into particleboard, make animal bedding, or put builders in touch with demolition contractors who could resell the wood.

Yume Food, on the other hand, deals with perishables as a wholesaler of surplus food. They realized that when a food manufacturer finishes a production run and pipes need to be emptied, the leftovers are only being used for low-grade pig feed. Yume wanted to turn these discontinued product lines or edible byproducts into higher-value items in the food supply chain. However, there are safety risks, brand concerns about protecting intellectual property, and a lack of time to find solutions to bring such byproducts to market.

There may not be the internal catalyst at the manufacturers to spend the time doing it . . . We can do a lot of the leg work on the demand side to find a new home for these products . . . then promote and replicate it to other manufacturers.

(Yume Food respondent)

After the material was segregated, Yume recognized ways that it could be reused. Now, they furnish alternative buyers for reprocessing and redistribution.

We'll make sure . . . if it's running through a pipe, the chocolate or honeycomb out of a pie, that they can put it into a particular package, maintain food safety and transport it to a new place.

(Yume Food respondent)

Good360 similarly extracts value from surplus items by recovering unsold but non-perishable goods for redistribution to registered charities. Demand for personal care items rose over COVID-19 and more recently due to the higher cost of living.

That's our model, matching up new merchandise with people who need them . . . Nobody knows there is an abundance of unsold goods.

(Good360 respondent)

Good360's staff continuously endeavours to enlarge their corporate outreach network. They established an efficient business model whereby items may be directly shipped to recipients in their original packaging through Good360's local store program. Donors have the flexibility to give to certain causes listed on Good360's website, such as matching a toy donor with a children's charity. The only cost for these orders is charging a nominal fee for shipping and handling.

The grant, however, funded merchandise that needed to be forwarded to Good360's warehouse for repackaging because it was not presented in a suitably sized container for a donee. Under those circumstances, Good360's volunteers will break down the items and reuse whatever packaging material is possible to assemble and ship orders to their members. Personnel are very conservative in minimizing Good360's purchasing and transport, and they offer customers a click-and-collect option to retrieve goods directly from their warehouse.

The business models in the cases demonstrate that staff acted with ingenuity beyond typical circular methods. Moreover, the organisations were at different stages of their own business life cycle when they engaged in Circulate projects. This indicates a likelihood of greater strategic planning and operational growth in the future. They were happy to share their successful outcomes across traditional media and online communication platforms.

> *We're continuing to monitor the sites from the Circulate program. It's gone from pilot into an early commercialization phase. We have an international network. Therefore, anything that we're doing here that's relevant, we promote overseas as well ... We're involved in some major projects ... in the United States and China ... The learnings and the findings from this project have a ripple effect in the international market.*
>
> (CORE respondent)

4.2. Impacts

Since the grantees had to report on their achievements as stipulated by the EPA to receive funding instalments, there is confidence that the projects succeeded. However, respondents sometimes admitted that the expected resource recovery took longer than predicted to reach early milestones. Within a year those participants acknowledged that larger, long-term outcomes were accomplished.

> *Overall, you're getting lifespan efficiencies from reduced removal and installation costs ... You get superior performance and longer-lasting filters ... Councils don't have to change them and buy more sand to replace a system every five years because ours will last 15 years on average.*
>
> (CORE respondent)

Targets could exceed expectations. CORE managed to use 1450 tons of material over its projected goal to eliminate 816 tons of waste. They installed more biofilters for councils and placed new orders with farms during the project. That had a positive knock-on effect on the environment with improved filtration systems and avoided emissions from shipping sand. Circular Centre also mitigated carbon emissions by preventing the transport of materials overseas, and the company calculated that reduced expenses would occur from installing the robotic arm that would expedite source separation.

Circular Centre estimated that it would lower its costs with the advanced technology to eliminate 168 tons of commercial textile waste from 3.50 AUD per kilo of material down to a minimum of 0.50 AUD. Wild Blue Consulting and SMA both avoided 7000 tons of wood going to landfill during their grant period, which helped their clients to save higher costs of disposal.

> *It gave them access to a recycler that could offer a lower rate to take their wood waste away. For their wood waste to go to landfill, they'd get charged a lift fee plus a disposal fee per ton. The rate, I think, at that time was between 250–300 AUD a ton, whereas the recycler was charging 70 AUD a ton.*
>
> (SMA respondent)

Using recycled wood can lessen reliance on natural gas or coal. Wild Blue Consulting and SMA assessed those savings through life cycle assessments. They presented these benefits to clients to demonstrate avoided emissions and present opportunities to gain carbon credits.

> *Using recycled wood for particleboard reduces the natural gas demand. That's one of the main reasons the manufacturers like using it, because the moisture content is around 10 per cent, whereas with virgin wood, that contains wood stuff residues from sawmills. It has about 50 per cent moisture ... One place this material went to was Vales Point up in*

the Hunter Valley, and they use up to 5 per cent wood to displace the black coal. They got renewable energy credits for doing that.

(SMA respondent)

Yume Food turned the costs of dairy production into higher profits by selling new consumer products for greater revenue than animal feed. And Good360 created economic value from undesired inventory.

We've committed to reduce 400 tons of food waste. And I think what we recognised when we do our calculation on CO_2, it varies heavily depending on the product. Meat is obviously much more intensive.

(Yume Food respondent)

The project outputs also captured social benefits for the communities and companies. SMA said the truss employees gave feedback that indicated how proud they felt to participate in the wood recovery. Good360 had many corporate donors reach out to volunteer time to work in their warehouse to make their 'Empower Packs' for charities, whereas Wild Blue Consulting went into the field to work with communities. They set up workshops at schools to teach parents in the local community how to recirculate food waste to grow produce. Hence, the grantees operated profit-for-purpose businesses.

4.3. Grants and Co-Governance

Many respondents thought the grant process provided good guidance on how much the NSW EPA was prepared to reimburse them. However, some were frustrated by delays due to COVID-19 or by resistance from the government when further financial support was needed to advance IE.

On the positive side . . . I think that becoming aware of what's happening, by promoting sustainability and by industrial ecology or Circulate, it all adds to it. So, the government impetus has certainly been beneficial.

(Wild Blue Consulting respondent)

Overall, the grants let them seize opportunities to leverage economies of scale. They established networks by engaging in joint meetings with other grantees that helped them to share knowledge and synergies to expand IE.

It gives us the ability to be able to take on a project that would cost the same for each of those members to do the project and they'd all be replicating . . . We bring a lot to the table with in-kind contributions and so forth. We're able to, on behalf of industry, do a project at a lot less cost . . .

(CORE respondent)

4.4. Challenges and Inspiration

Undertaking IE initiatives nevertheless places risks on SMEs. They might just break even after factoring in their in-kind contributions. Also, it was difficult to convince their clients to change their practices since corporations are risk-averse and reluctant to engage in recycling for relatively small dollars or to sign new contracts with waste management companies.

Grantees thought there were limitations regarding what the NSW EPA scheme tackled. They made constructive suggestions for future improvement specifically to add excluded waste materials and to give more precise definitions about them in the grant applications.

Organic processing is a very limiting way of looking at recycling for wood, you don't capture all the purposes . . . There are different types of wood waste, and it should be split up so that it is not treated as if there's only one aspect of it . . .

(SMA respondent)

We know that food is wasted and doesn't always get to market. So why do we assume every other category got to market? That's a big blind spot.

(Good360 respondent)

Commonly, grantees faced logistical hurdles in diverting waste. They said it is easier to source outlets to forward used materials in the cities but very difficult to access new markets in regional areas.

It's done at a local facility [in Sydney], generally where the materials have been recycled, or at a third-party manufacturing facility . . . It's where they bring all the different recycled materials from the different players to one place to build a filter out of them there.

(CORE respondent)

It was recommended that local governments provide additional forms of assistance. Since councils operate waste facilities, local government could help the companies to achieve greater economies of scale and convenience by acting as an intermediary to facilitate sending waste to local reprocessing facilities. That would require greater investment, but it would take advantage of the proximity in reducing transport costs that can offset profit margins.

Consumers must play their part to co-create IE ecosystems besides having the businesses and government shoulder all the responsibility. Education is an important component to change the mindsets of producers and consumers to break the 'smash and trash' mentality and build acceptance for new IE systems. Often the impetus to recycle came from a grantee who had to visit companies that had waste materials, identify what was reusable, teach those businesses how to separate waste, and connect them with recyclers who offer speed, reliability, and an attractive price.

So, what we did is that we stepped into that position ourselves and became the enablers. For example, with the organic food waste [Plate to Paddock], we developed a project and commercialised it.

(Wild Blue Consulting respondent)

Businesses could be leery of participating in recycling due to extra scrutiny that might come from the EPA to ensure they meet regulations. One grantee said certain policies for transporting waste and the Protection of the Environment Operations Act are stringent. Companies want to avoid any potential breaches.

Lastly, we often set up the relationship, we make people aware of the opportunities, and then we didn't get the kudos for having made that established relationship because either the project finished before that relationship was fully embedded . . . or because the business said, 'We don't know each other . . .' Because basically, they don't want the EPA looking into their books.

(Wild Blue Consulting respondent)

Although the cases brought greater uptake in eco-efficiencies, more needs to be accomplished. They looked at overseas business models for ideas.

We keep our finger on the pulse of what's happening elsewhere . . . how people are incorporating bioproducts and surplus into new product development. There's a lot of specific examples in the brewing area—making spent grain into bread or muesli bars and seeing business trends with other surplus products.

(Yume Food respondent)

Grantees either replicated existing business models that they learned about from overseas or reframed them to suit their industry and circumstances while they tried to make their projects viable to lead to future growth. Some of the projects were original and provided global leadership, such as CORE.

They'd been operating for over 30 years in the US . . . We needed a solution here, so I started it. In this very short time of five years, we've distributed almost 150 million AUD in goods donated to Good360.

(Good360 respondent)

We took some inspiration from those kind of conversions in making sneakers from used materials and creating products out of old fishing nets from examples happening around the world.

(Yume Food respondent)

5. Discussion

The cases aimed for their projects to be capable of translating learnings and best practices into larger, standardised practices. However, their ability to expand hinged on making the projects cost-effective and attracting eco-conscious customers.

There are growing reasons for organizations to embrace IE for diverting large quantities of waste materials and curtailing the use of raw materials. In the C&D sector, buildings consume approximately 50 per cent of the world's raw materials and cause 35 per cent of their waste [39].

By contrast, the circular economic model is regenerative [45]. Under this model, resources, emissions, and energy are minimised by slowing, closing, and narrowing material and energy loops through cyclical systems in which products and materials are kept in use, and waste is designed out. The circular economy is integral to reducing carbon emissions through better use and management of resources. There is a business case for aligning with organisations that offer IE ecosystems because they offer sustainable growth. Companies may be able to lower the cost of inputs and maximise the value of waste products by retaining resources, components, or parts.

The cases adopted circularity to develop ecosystems based on government assistance. Offering more incentives can increase the capacity for repurposing materials and adopting new technologies and processes beyond what the cases put into practice. This is demonstrated by upcyclers who are trialling the use of paper mill waste to neutralise acidic water at dams at mine sites for rehabilitation [36]. Mining has been a leading sector of the Australian economy and certainly would benefit from these kinds of processes across Australia.

The findings show that co-management in IE based on investment represents a win-win for the government, business, and the public. It validates evidence from overseas where one study discovered public subsidies positively and significantly promoted innovation input and output of 2600 Chinese SMEs [46], and another study indicated research and innovation funding benefitted 1860 European Union SMEs [47]. Recent research from a study in Iran underscores that green entrepreneurship can be a strategically effective way to foster circularity, but organizational enablers are required to adopt such entrepreneurship in manufacturing SMEs [48].

In this study, the research filled a gap by demonstrating how the government incentives acted as enablers, opening up the conditions for small and medium enterprises to seize innovative opportunities, particularly to increase technology and other capabilities for circularity. These results align with a study [49] that found entrepreneurship in cities using sustainable and digital technologies leads to greater capabilities for sustainability.

Accelerating the paradigm shift to a circular economy requires extending life cycle design and production that depend on having available expertise to make it commercially viable. Velenturf et al. [50] contend that technologies should be designed and redesigned for remanufacturing, using less waste, carbon, and energy, and instilling the infrastructure to facilitate the capacity for IE.

Currently, only nine per cent of the world is circular [51]. Since resource needs are pervasive and poised for higher extraction [18], that means a profound gap exists for IE that can be filled through more public–private partnerships.

This research contributes by demonstrating cooperation between governments and business enabled technological and other forms of innovation in SMEs. The approach of offering investment and networking to SMEs lent the necessary support to co-create IE ecosystems with the government. It deserves greater attention because this method can expand circularity in cities and regions to meet growing societal and business needs.

This study thus extends theoretical constructs on innovation ecosystems with real-world applications of sustainable entrepreneurship from the cases seen in the model in Figure 5. In these cases, implementation by the companies was reliant upon the grants. The results show the new opportunities that were afforded planted seeds of change in cities and regions to transform production and consumption patterns if support is provided to SMEs to start up IE operations. The grant scheme set in motion having grantees work in partnerships with the government and other supply chain actors, harnessing new methods of production and consumption to reduce externalities for many waste streams. The grantees exploited opportunities to repurpose food, timber, textiles, plastics, and other used and new goods.

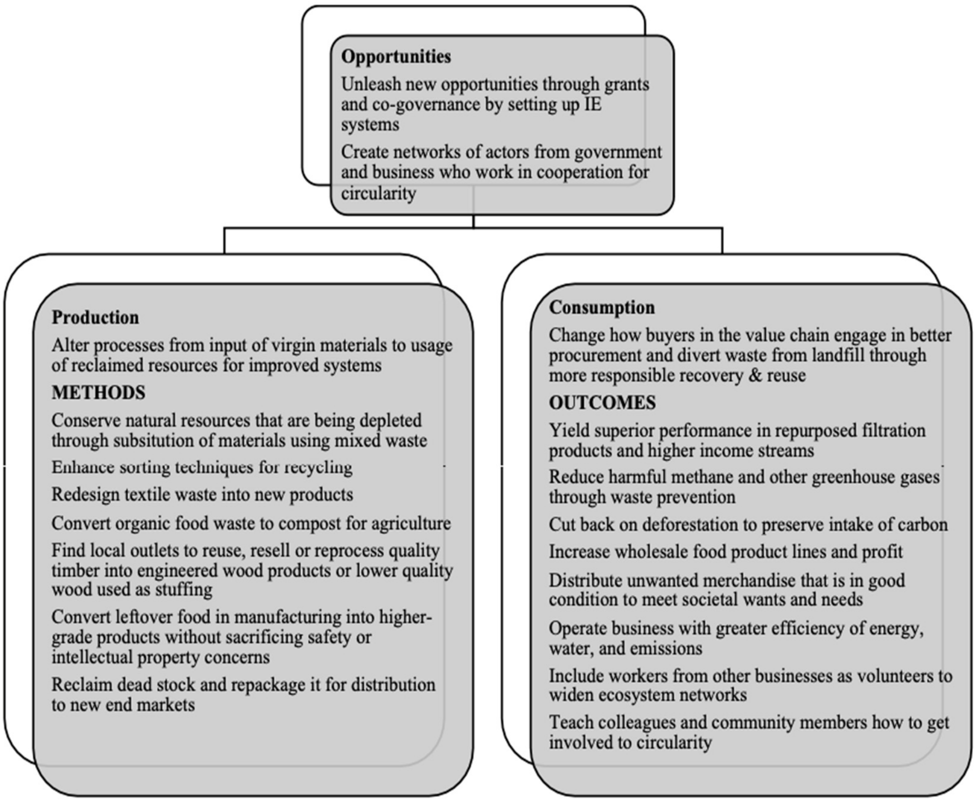

Figure 5. Model of the value proposition of engaging in IE.

Circulate inspired the creation of new business models that wider businesses can mimic, or different SMEs can apply for newer grants offered by the NSW EPA to arrive at their own solutions in better waste management practices under the current waste and recycling infrastructure programs, such as Remanufacture NSW [52]. These subsidies respond to the passage of the Australian Government's Recycling and Waste Reduction Act 2020, which encourages product stewardship [53].

The novelty of this research is that it gives practitioners suggestions on how to adopt sustainable entrepreneurship to enable innovation for reprocessing and extending life cycles of products. Doing so enhances the stocks and flows of resources through supply chains while limiting energy, water, and the extraction of raw materials. It confirms that cooperation in public–private partnerships increases the value of resources and lessens the hazards from disposal in landfills among other benefits. Indications are more of these arrangements should be formulated in conjunction with passing policy to forge deeper alliances between government and business to transition to circularity. Reprocessing waste helps meet future energy and natural resource demands and provides concrete measures to satisfy global policy agendas. Moreover, IE contributes to the adoption of the

Sustainable Development Goals (SDGs), particularly SDG 12, Responsible Consumption and Production [54].

6. Conclusions

Despite the benefits of IE supported by the literature coupled with predictions of dwindling resources, many governments and the private sector have not changed their business-as-usual approach to exploit its potential [5]. Future research should be conducted to investigate actions to facilitate behaviour change, such as through teaching research and design for IE [55], to transfer this knowledge and forge careers for a restorative future.

Further, it is important to look at how other regions currently enact measures and programs for IE. This study was limited to one state in Australia that has a fragmented waste management and resource recovery landscape, so it does not account for progress in national or global markets. However, the trend for resource recovery is moving upward to 63 per cent in 2020–2021 [56].

A cross-country analysis could be performed to track the performance of SMEs that receive government assistance for IE. It would be insightful to detect what are the key performance indicators and which ones maximize returns on investment.

To build resilience, it would also be helpful for countries to transition to economic models beyond the production of GDP. New Zealand unveiled the first global budget that accounts for well-being over purely economic development [57]. Recently, Australia put forth its own framework that includes emissions reduction targets and climate change policy [58]. This signals a positive step to integrate more capital growth measures than financial output, as it targets sustainability.

However, instilling IE at a substantial scale requires time, advanced technology, and the collective efforts of multiple stakeholders. Partners need to reconcile competing philosophies and incompatibilities in remanufacturing, regulatory impediments, or market-based barriers. Any IE model must account for production risks. If interruptions or delays ensue in manufacturing and one business becomes dependent upon another for exchanging energy, water, or materials, then problems need to be overcome [59]. Linking robotics with remanufacturing offers a method to resolve this issue. Smart technology, such as Siemens PLM Software [11], is being invented to deploy digital restructuring that relays manufacturing instructions between departments in real-time for quick troubleshooting.

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References

1. Fischer-Kowalski, M.; Swilling, M.; Von Weizsacker, E.U.; Ren, Y.; Moriguchi, Y.; Crane, W.; Krausmann, F.K.; Eisenmenger, N.; Giljum, S.; Hennicke, P.; et al. *Decoupling: Natural Resource Use and Environmental Impacts from Economic Growth*; A Report of the Working Group on Decoupling to the International Resource Panel; United Nations Environment Programme: Nairobi, Kenya, 2011.
2. UNEP. ISWA Global Waste Management Outlook. 2015. Available online: http://apps.unep.org/publications/index.php?option=com_pub&task=download&file=011782_en (accessed on 5 May 2023).
3. Velenturf, A.; Purnell, P. Resource recovery from waste: Restoring the balance between resource scarcity and waste overload. *Sustainability* **2017**, *9*, 1603. [CrossRef]
4. Elisha, O.D. Moving beyond take-make-dispose to take-make-use for sustainable economy. *Int. J. Sci. Res. Educ.* **2020**, *13*, 497–516.
5. Esposito, M.; Tse, T.; Soufani, K. Introducing a circular economy: New thinking with new managerial and policy implications. *Calif. Manag. Rev.* **2018**, *60*, 5–19. [CrossRef]

6. Layton, A.; Bras, B.; Weissburg, M. Industrial ecosystems and food webs: An expansion and update of existing data for eco-industrial parks and understanding the ecological food webs they wish to mimic. *J. Ind. Ecol.* **2016**, *20*, 85–98. [CrossRef]
7. Baldassarre, B.; Schepers, M.; Bocken, N.; Cuppen, E.; Korevaar, G.; Calabretta, G. Industrial Symbiosis: Towards a design process for eco-industrial clusters by integrating circular economy and industrial ecology perspectives. *J. Clean. Prod.* **2019**, *216*, 446–460. [CrossRef]
8. Chertow, M.; Zhu, J.; Moye, V. Positive externalities in the urban boundary: The case of industrial symbiosis. In *The Routledge Handbook of Urbanization and Global Environmental Change*; Routledge: London, UK, 2015; pp. 494–511.
9. Kalundborg Symbiosis. Surplus from Circular Production. Available online: https://www.symbiosis.dk/en/ (accessed on 5 May 2023).
10. Hong, J.; Hong, S.; Wang, L.; Xu, Y.; Zhao, D. Government grants, private R&D funding and innovation efficiency in transition economy. *Technol. Anal. Strateg. Manag.* **2015**, *27*, 1068–1096.
11. Siemens PLM Software. MindSphere. 2017. Available online: https://iiot-world.com/wp-content/uploads/2017/03/Siemens_MindSphere_Whitepaper.pdf (accessed on 5 May 2023).
12. Stock, J.R. Reverse logistics. In *Council of Logistics Management*; Sturgess: Oak Brook, IL, USA, 1992; pp. 1–10.
13. Rogers, D.S.; Tibben-Lembke, R. *Going Backward: Reverse Logistics Trends and Practices*; RLEC Press: Pittsburgh, PA, USA, 1999.
14. McDonough, W.; Braungart, M. *Cradle to Cradle: Remaking the Way We Make Things*; No. 504.064.4; North Point Press: New York, NY, USA, 2002.
15. Ellen MacArthur Foundation. The Butterfly Diagram: Visualising the Circular Economy. 2017. Available online: https://ellenmacarthurfoundation.org/circular-economy-diagram (accessed on 5 May 2023).
16. Mulrow, J.S.; Derrible, S.; Ashton, W.S.; Chopra, S.S. Industrial symbiosis at the facility scale. *J. Ind. Ecol.* **2017**, *21*, 559–571. [CrossRef]
17. Bleischwitz, R.; Spataru, C.; VanDeveer, S.D.; Obersteiner, M.; van der Voet, E.; Johnson, C.; Andrews-Speed, P.; Boersma, T.; Hoff, H.; Van Vuuren, D.P. Resource nexus perspectives towards the United Nations Sustainable Development Goals. *Nat. Sustain.* **2018**, *1*, 737–743. [CrossRef]
18. Dobbs, R.; Oppenheim, J.; Thompson, F.; Brinkman, M.; Zornes, M. *Resource Revolution: Meeting the World's Energy, Materials, Food, and Water Needs*; McKinsey Quarterly and Company: Summit, NJ, USA, 2011.
19. Morgan, J. *The Great Resource Price Shock*; Alliance: Green London, UK, 2014.
20. Sakthipriya, N. Plastic waste management: A road map to achieve circular economy and recent innovations in pyrolysis. *Sci. Total Environ.* **2022**, *809*, 151160.
21. Hoang, A.T.; Pandey, A.; Lichtfouse, E.; Bui, V.G.; Veza, I.; Nguyen, H.L.; Nguyen, X.P. Green hydrogen economy: Prospects and policies in Vietnam. *Int. J. Hydrogen Energy* **2023**, *43*, 31049–31062. [CrossRef]
22. Chen, G.; Chen, Z. On reverse logistics management dimension of government and market: From the perspective of circular economy. In Proceedings of the 2010 3rd International Conference on Information Management, Innovation Management and Industrial Engineering, Kunming, China, 26–28 November 2010; Volume 3, pp. 388–391.
23. Stiglitz, J.E. The role of the state in financial markets. *World Bank Econ. Rev.* **1993**, *7*, 19–52. [CrossRef]
24. Wallsten, S.J. The effects of government-industry R&D programs on private R&D: The case of the Small Business Innovation Research program. *RAND J. Econ.* **2000**, *31*, 82–100.
25. Toivanen, O.; Niininen, P. *Investment, R&D, Subsidies and Credit Constraints*; HSEBA Working Papers No. W-264; Helsinki School of Economics: Helsinki, Finland, 2000.
26. Antonelli, C. A failure-inducement model of research and development expenditure: Italian evidence from the early 1980s. *J. Econ. Behav. Organ.* **1989**, *12*, 159–180. [CrossRef]
27. Jia, L.; Nam, E.; Chun, D. Impact of Chinese government subsidies on enterprise innovation: Based on a three-dimensional perspective. *Sustainability* **2021**, *13*, 1288.
28. Fan, G.; Wang, X.; Ma, G. Contribution of marketization to China's economic growth. *Econ. Res. J.* **2011**, *9*, 1997–2011.
29. European Commission. Circular Economy. 2020. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1583933814386&uri=COM:2020:98:FIN (accessed on 5 May 2023).
30. Rizos, V.; Behrens, A.; Van der Gaast, W.; Hofman, E.; Ioannou, A.; Kafyeke, T.; Flamos, A.; Rinaldi, R.; Papadelis, S.; Hirschnitz-Garbers, M.; et al. Implementation of circular economy business models by small and medium-sized enterprises (SMEs): Barriers and enablers. *Sustainability* **2016**, *8*, 1212. [CrossRef]
31. Hobson, K. The limits of the loops: Critical environmental politics and the circular economy. In *Trajectories in Environmental Politics*; Routledge: London, UK, 2022; pp. 158–176.
32. People's Republic of China. Circular Economy Promotion Law of the People's Republic of China. 2012. Available online: http://www.lawinfochina.com/display.aspx?id=7025&lib=law (accessed on 5 May 2023).
33. Kim, S.-Y.; Thurbon, E.; Tan, H.; Mathews, J. China Succeeds in Greening Its Economy Not Because, in Spite of, Its Authoritarian Government. *The Conversation*. 28 May 2019. Available online: https://theconversation.com/china-succeeds-in-greening-its-economy-not-because-but-in-spite-of-its-authoritarian-government-115568 (accessed on 5 May 2023).
34. Australian Government. National Waste Policy. 2018. Available online: https://www.environment.gov.au/system/files/resources/d523f4e9-d958-466b-9fd1-3b7d6283f006/files/national-waste-policy-2018.pdf (accessed on 23 August 2023).

35. Australian Government. Australia's Waste and Resource Recovery Infrastructure. 2021. Available online: https://www.dcceew.gov.au/environment/protection/waste/publications/national-waste-reports/2013/infrastructure#:~:text=The%2048%20million%20tonnes%20of,resource%20recovery%20facilities%20and%20landfill (accessed on 23 August 2023).
36. NSW EPA. Circulate, Industrial Ecology Program. 2022. Available online: https://www.epa.nsw.gov.au/your-environment/recycling-and-reuse/business-government-recycling/circulate-business (accessed on 23 August 2023).
37. NSW EPA. Circulate: Industrial Ecology Grant Program. 2018. Available online: https://www.epa.nsw.gov.au/-/media/epa/corporate-site/resources/wastegrants/17p0477-circulate-guidelines-for-applicants.pdf (accessed on 23 August 2023).
38. Pickin, J.; Wardle, C.; O'Farrell Nyunt, P.; Donovan, S. *National Waste Report*; Department of the Environment and Energy, Blue Environment Pty Ltd.: Melbourne, Australia, 2020.
39. UNEP. *2022 Global Status Report for Buildings and Construction: Towards a Zero-Emission, Efficient and Resilient Buildings and Construction Sector*; UNEP: Nairobi, Kenya, 2022.
40. Tollefson, J. COVID curbed carbon emissions in 2020—But not by much. *Nature* **2021**, *589*, 343. [CrossRef]
41. Sharif, N. Emergence and development of the National Innovation Systems concept. *Res. Policy* **2006**, *35*, 745–766. [CrossRef]
42. Yin, R.K. *Case Study Research: Design and Methods*; Sage: Thousand Oaks, CA, USA, 2009; Volume 5.
43. Gustafsson, J. Single Case Studies vs. Multiple Case Studies: A Comparative Study. 2017. Available online: https://www.diva-portal.org/smash/get/diva2:1064378/FULLTEXT01.pdf (accessed on 13 September 2023).
44. Eisenhardt, K.M.; Graebner, M.E. Theory building from cases: Opportunities and challenges. *Acad. Manag. J.* **2007**, *50*, 25–32. [CrossRef]
45. Ellen MacArthur Foundation. Completing the Picture: How the Circular Economy Tackles Climate Change. 2021. Available online: https://emf.thirdlight.com/file/24/cDm30tVcDDexwg2cD1ZEcZjU51g/Completing%20the%20Picture%20-%20How%20the%20circular%20economy%20tackles%20climate%20change.pdf (accessed on 5 May 2023).
46. Xiang, D.; Zhao, T.; Zhang, N. Does public subsidy promote sustainable innovation? The case of Chinese high-tech SMEs. *Environ. Sci. Pollut. Res.* **2021**, *28*, 53493–53506.
47. Čučković, N.; Vučković, V. The effects of EU R&I funding on SME innovation and business performance in new EU member states: Firm-level evidence. *Econ. Ann.* **2021**, *66*, 7–41.
48. Soleimani, M.; Mollaei, E.; Beinabaj, M.H.; Salamzadeh, A. Evaluating the enablers of green entrepreneurship in circular economy: Organizational enablers in focus. *Sustainability* **2023**, *15*, 11253. [CrossRef]
49. Dana, L.P.; Salamzadeh, A.; Hadizadeh, M.; Heydari, G.; Shamsoddin, S. Urban entrepreneurship and sustainable businesses in smart cities: Exploring the role of digital technologies. *Sustain. Technol. Entrep.* **2022**, *1*, 100016. [CrossRef]
50. Velenturf, A.; Purnell, P.; Tregent, M.; Ferguson, J.; Holmes, A. Co-producing a vision and approach for the transition towards a circular economy: Perspectives from government partners. *Sustainability* **2018**, *10*, 1401. [CrossRef]
51. Circular Economy. The Circularity Gap Report 2019. The Platform for Accelerating the Circular Economy (PACE). 2019. Available online: https://docs.wixstatic.com/ugd/ad6e59_ba1e4d16c64f44fa94fbd8708eae8e34.pdf (accessed on 5 May 2023).
52. NSW EPA. Remanufacture NSW. 2023. Available online: https://www.epa.nsw.gov.au/working-together/grants/infrastructure-fund/remanufacture-nsw (accessed on 23 August 2023).
53. Australian Government, Department of Agriculture. Water and the Environment Annual Report 2021-21: Recycling and Waste Reduction Act 2020. Available online: https://www.transparency.gov.au/annual-reports/department-agriculture-water-and-environment/reporting-year/2020-21-27#:~:text=A%20key%20objective%20of%20the,%2C%20co%2Dregulatory%20and%20mandatory (accessed on 23 August 2023).
54. United Nations. Goal 12: Ensure Sustainable Consumption and Production Patterns. 2021. Available online: https://www.un.org/sustainabledevelopment/sustainable-consumption-production/ (accessed on 5 May 2023).
55. Curtin University. Sustainable Engineering Group. Available online: http://seg.curtin.edu.au/ (accessed on 5 May 2023).
56. Blue Environment. National Waste Report 2022. 16 December 2022. Available online: https://www.dcceew.gov.au/sites/default/files/documents/national-waste-report-2022.pdf (accessed on 13 September 2023).
57. New Zealand Government. The Wellbeing Budget. 30 May 2019. Available online: https://treasury.govt.nz/sites/default/files/2019-05/b19-wellbeing-budget.pdf (accessed on 5 May 2023).
58. Australian Government. Measuring What Matters: Australia's First Wellbeing Framework. 2023. Available online: https://treasury.gov.au/sites/default/files/2023-07/measuring-what-matters-statement020230721_0.pdf (accessed on 23 August 2023).
59. Beulque, R. Industrial Ecology: Flow Management and Feasibility of Synergies. 8 June 2017. Available online: https://www.youtube.com/watch?v=vc6Qo8ttXQw (accessed on 5 May 2023).