



Windows of opportunity: The power dynamics in the disposable nappy regime and opportunities for niche innovations

Jason Graham-Nye^{a,*}, Nick Florin^b, Monique Retamal^b

^a Institute for Sustainable Futures, University of Technology, Sydney, Australia

^b University of Technology, Sydney, Australia

ARTICLE INFO

Keywords:

Sustainability transitions
Disposable nappies
Compostable nappies
Niche-regime interactions
Windows of opportunity

ABSTRACT

This paper studies niche-regime dynamics in sustainability transitions in the disposable nappy industry in Australia. Disposable nappies generate a disproportionate amount of plastic waste relative to the per capita usage of the product. In the 60 years since disposable nappies were introduced into the market, niche innovators attempting to offer more sustainable solutions have been unable to challenge the dominant market position of disposable nappies. Little attention has been paid to the dynamics of this industry despite the growing plastic waste crisis and the emergence of new niche innovations.

In this study, we apply the Multi-Level Perspective (MLP) to the disposable nappy category for the first time. We adopt the “windows of opportunity” framework that sits within MLP to understand niche-regime dynamics in the nappy industry. The findings of this study revealed several significant barriers that niche nappy innovators need to overcome to destabilise regime-level actors and become mainstream. Achieving price parity and matching performance and convenience are the most significant factors. A new policy intervention in the Australian state of New South Wales banning the inclusion of compostable biofilms in household Food Organics Garden Organics (FOGO) waste collections also poses an immediate regulatory barrier.

1. Introduction

This paper explores the prospect of sustainability transitions in the disposable baby nappy industry. Since their introduction in 1961, up to 95% of parents in the Global North use disposable baby nappies (Klein, 2018). As a result, this nappy product choice has become the norm for multiple generations of parents. The most recently available consumer market research shows that annual production of disposable baby nappies reached 167 billion units in 2017 (Olivo, 2017). The production and consumption of plastic disposable baby nappies has caused substantial damage to the environment since their introduction 60 years ago (Notten et al., 2021). There are two major environmental impacts caused by disposable baby nappies: the upstream use of oil to manufacture the product, and downstream disposal in landfills. Landfills receive significant amounts of organic matter which generates greenhouse gas (GHG) emissions. Used nappies also pollute waterways in countries where there are limited formal waste management systems (Khoo et al., 2019). The United Nations Environment Programme described the product as one of the largest contributors to plastic waste globally (Notten et al., 2021). The announcement in March 2022 by the

United Nations Environment Assembly of a global, legally binding plastic treaty to end plastic pollution indicates the scale of the plastic waste problem and the desire to address this source of pollution (UNEP, 2022). Relative to the well-documented environmental damage caused by single-use plastic shopping bags (Weinstein, 2010; Wagner, 2017; Global Health Metrics, 2018), disposable baby nappies represent a far larger source of pollution on a per user basis. However, the environmental impacts of disposable nappies and the possibility of alternatives have yet to gain a commensurate level of attention in academia and wider society.

There are four alternatives to disposable nappies. They are reusable nappies, eco-friendly nappies, hybrid nappies and compostable nappies. Reusable nappies were the first nappy product choice for parents since their inception in the US in 1887 (United States Patent Office, 1887) up until the introduction of disposable nappies in 1961 (Ratnapandian and Warner, 1996). Reusable nappies are made of washable materials that are purchased once and used and washed repeatedly during the years a baby uses nappies. There is evidence to suggest that reusable nappies offer less negative environmental impacts than disposable nappies (Garrett et al., 2008; Klein, 2018; Notten et al., 2021). This is chiefly due

* Corresponding author.

E-mail address: Jason.W.Graham-Nye@student.uts.edu.au (J. Graham-Nye).

<https://doi.org/10.1016/j.clrc.2024.100169>

Received 25 October 2023; Received in revised form 30 December 2023; Accepted 2 January 2024

Available online 3 January 2024

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to their ability to be washed and reused over the life of a baby or multiple babies. The negative effects of water and energy usage for reusable nappies are outweighed by the extraction of oil to make the plastic in disposable nappies and their disposal in landfills where they may take up to 500 years to degrade (Sanderson, 2008, Wang et al., 2016; Khoo et al., 2019). However reusable nappies have been unable to challenge the dominant market position of disposable nappies. Today, they represent just 0.7% of the value of the disposable nappy market (Market Growth Reports, 2023).

Over the past two decades eco-friendly nappies have been developed that use some compostable materials along with incumbent plastic films. However, assuming the entire nappy is disposed of in landfill, the environmental benefits are unlikely to be significantly different than regular disposable nappies. Eco-friendly nappies have been unable to gain significant market share due to their price premium. More recently, hybrid nappies have been developed that include an outer washable pant, and an absorbent, industrially compostable liner¹ (Walker, 2006). Hybrid nappies have been commercialised and have faced the same difficulties that reusable and eco-friendly nappies have experienced in gaining mainstream appeal. Compostable nappies using a reusable, washable fastening mechanism (Klein, 2018) have also been developed but are yet to be fully commercialised. Unlike the other alternatives, compostable nappies are offered along with a full service including the delivery, collection and composting by the manufacturer or a third party. This full service is also known as a “Product Service System” in academic literature and is a business model that integrates a product and service providing a complete solution to meet customer’s needs and create value (Pieroni et al., 2019). The concept has increasingly appeared in Circular Economy literature as a way to provide products in a more sustainable way. In Australia, the compostability of this product has been endorsed by Australia’s peak composting-industry body, Compost Australia (Wadewitz, 2009). The compostable nappy product-service system is the subject of this study. Given their early stage of development, there has been little research conducted to better understand the dynamics between the dominant disposable nappy and this new alternative product and service format. This study aims to understand how a compostable nappy with a reusable fastener and service could challenge the dominant market position of disposable nappies.

The Multi-Level Perspective (MLP) (Kemp et al., 1998; Geels, 2004; Geels, 2011) has gained prominence as a useful theoretical lens to understand the dynamics of sustainability transitions. Sustainability transitions are large and complex and occur at a global scale which requires systemic change. This includes changes across multiple sectors (technology, policy, markets, user practices, infrastructure, cultural meaning and scientific knowledge) involving multiple actors (companies, policy makers, consumers, society and researchers). MLP describes interactions between niche innovations at the micro-level, technological regimes at the meso-level, and sitting above these levels, the landscape at the macro-level. The socio-technical regimes at the meso-level represent the current status quo across policy, infrastructure, institutions and corporations. Niche innovations may develop and destabilise the regime, becoming mainstream themselves. The landscape may also destabilise

the regime, creating opportunities for niche actors to join the regime (Geels, 2004). Geels (2002), Nill and Kemp (2009) and Smith et al. (2010) further developed MLP by identifying “windows of opportunity” opening and subsequently closing for niche sustainability innovations to destabilise the regime and become mainstream. This “windows” approach is growing in popularity and has been applied by researchers to understand niche innovation across a wide range of subject areas. They include infrastructure, online retail and transportation (Normann, 2015; Tongur and Engwall, 2017; Dannenberg et al., 2020; Becker et al., 2022; Szasz et al., 2022). This approach provides a compelling retrospective of moments in time when a niche innovation may have been able to destabilise the regime but was ultimately unsuccessful. Understanding the dynamics of these historical opportunities for sustainability transitions may provide insights for future opportunities for sustainability transitions to take hold. In the context of nappies, challenging the dominant market position of disposable nappies by alternative products can be characterised as a sustainability transition. This study applies MLP to nappies for the first time expanding on its previous systems-level applications to now include a product-level analysis. In doing so, new insights about the strength of the nappy industry regime and the possible role of policy intervention emerge, filling knowledge gaps previously in the literature.

In this research, 12 semi-structured interviews were conducted with stakeholders who sit at the regime and niche levels of the nappy industry. Analysis of these interviews was then conducted through the lens of MLP with a specific view to identifying examples of windows of opportunity. This paper makes four contributions to the field surrounding the dynamics of sustainability transitions. It is the first application of MLP to the nappy industry. It also contributes to an emergent body of literature applying MLP to a product category rather than a system. In addition, it uses the “windows” lens to understand niche-regime dynamics within the nappy industry. Lastly, it reflects on the lessons of the past to suggest how future windows of opportunity can be “wedged open” to accelerate sustainability transitions in the nappy industry.

The lead researcher has 20 years of commercial experience in the environmentally friendly nappy industry and has lived experience of developing and marketing products for the sustainable nappy sector. He acknowledges that this background will shape the lens through which he engages with this topic. In addition, he is aware that his identities including gender, age and family experience may influence his approach and interactions as part of this research. To address the potential for bias, he has engaged in critical reflection with co-authors and advisors who have different identities in terms of professional experience, disciplinary background, age and gender.

The structure of this paper is as follows: following this introduction in Section 1, Section 2 introduces the windows framework and describes how it applies to the nappy industry; Section 3 describes the methodology; Section 4 sets out the results and offers an analysis; Section 5 provides a discussion; and Section 6 offers concluding remarks.

2. Analytical framework

The compostable nappy industry is in its infancy. To date the development has been conducted by small, niche companies testing new compostable materials and conducting small pilots to gauge market responses. While the products hold promise to address the plastic waste issues caused by disposable nappies, they are early in the development stage. To become mainstream, they will need to challenge a large, well-established oligopoly of incumbent nappy manufacturers and related stakeholders. MLP is a theoretical framework well suited to this research task. MLP is a conceptual model for understanding sustainability transitions acknowledging the complexity and multiple dimensions of a socio-technical system. It was developed initially by Rip and Kemp (1998) and further refined by Geels (2002) in an attempt to understand how socio-technical transitions occur considering three levels of analysis within a socio-technical system. Geels (2011) describes the approach as

¹ Industrial composting is defined as “the process of converting organic waste from industrial sources into a valuable soil amendment through the breakdown of organic matter using aerobic decomposition.” It typically involves the use of specialized equipment to manage and control the process, such as enclosed composting systems, aerated static piles, and in-vessel systems. Industrial composting of organic materials helps to reduce the amount of waste sent to landfills, improve soil fertility, and reduce the need for synthetic fertilizers. Additionally, it can reduce emissions of environmentally harmful gases and provide a valuable source of compost for farms and other agricultural operations. Source: Bae, E., & Han, S. (2018). Industrial composting of organic waste: A review. *Renewable and Sustainable Energy Reviews*, 97, 803-817.

interactions between niche innovations at the micro level, technological regimes at the meso level and landscape factors at the macro level. The socio-technical regimes at the meso level represent the current status quo across policy, infrastructure, institutions and corporations. This has been described by Geels (2004) as the “deep structure” that offers stability to the system. Change is incremental in nature and path dependent at this level. They can however be vulnerable to influences of the socio-technical landscape at the macro level and niche-innovations at the micro level. Micro-level niche-innovations represent radical new offerings developed by R&D labs, incubators and start-up entrepreneurs and can come in the form of small-scale pilots and experiments (Geels, 2004; Smith and Raven, 2012). In this model, sustainable niche-innovations seek to have their innovations incorporated into or replace the existing technological regime. Smith and Raven (2012) labelled this incorporation of a niche innovation into the regime as an example of a “Fit and Conform” configuration while the niche innovation that entirely replaces a regime technology is an example of a “Stretch and Transform” innovation. Mylan et al. (2019) added a third category, namely a hybrid approach that has elements of both “Fit and Conform” and “Stretch and Transform”. The socio-technical landscape represents exogenous background factors including prevailing economic conditions, the price of commodities and global events. A recent example of such a factor is the Covid-19 pandemic. The durability of the meso level is significant with a multitude of lock-in mechanisms which reinforce the status quo and render many niche innovations ineffective in becoming mainstream (Geels, 2011).

Applications of MLP have to date been predominantly centred around systems-level transitions including energy, food provisioning, finance and transport (Mylan et al., 2016; Tongur and Engwall, 2017; Geddes and Schmidt, 2020; Lucas-Healey et al., 2022; Medina-Molina et al., 2022). There are relatively few examples of the application of MLP at a product category level (Becker et al., 2022; Sunio and Mateo-Babiano, 2022). Two exceptions include Morris, Kirwan et al. (2014) and Mylan et al. (2019). Morris et al. (2014) applied MLP to explore a more sustainable regime of meat provisioning. They did so by looking at Less Meat Initiatives (LMIs) as socially innovative niche projects. LMI's include campaigns such as Meat-Free Mondays and Meatless Mondays in the US and UK. This research showed the impact of a social innovation on the consumption of a mass-consumed, entrenched product not dissimilar to disposable nappies. Their work concluded that while LMI's had replicated and scaled up across the world, they have not destabilised regime-level meat consumption. The authors argued that this is because the initiative was too radical to become mainstream. In addition, while state actors, organisations and the media continued to promote a diet high in meat, the impact of LMIs was limited. LMIs are effective in raising awareness about a diet less dominated by meat. Mylan et al. (2019) using MLP took a historical view of the challenges faced by niche plant-based milk (PBM) innovators as they attempted to enter the liquid dairy milk regime. These are milks made from soy, nuts, legumes, seeds and grains. Their research showed a bi-directional dynamic between regime-level liquid dairy manufacturers and niche-level PBM producers. Rather than the well documented, one-way push upwards by the niche player pressuring the regime to incorporate their offerings, this research found the regime itself developing their own products or acquiring niche players. Building on previous studies, in this work we apply MLP to the specific product category of baby nappies. We do so in an effort to show new insights that can assist practitioners, researchers and policy makers address the growing disposable nappy waste problem.

Geels (2002), Nill and Kemp (2009) and Smith et al. (2010) developed the “windows-of-opportunity” framework to further explain niche-regime dynamics. While MLP describes a structure within which three socio-technical levels interact, the windows of opportunity approach adds a temporal element to further elaborate MLP. The framework describes a period of time where an opportunity emerges for niche innovations to destabilise the lock-in effects of the regime and

become mainstream. Examples of such windows opening include government interventions supporting niche innovations and landscape level factors such as pandemics and financial crises. Since first raised by Geels (2002), a growing number of researchers have applied the windows approach to understand the prospects of sustainability transitions. Nill and Kemp (2009) built on Geels' work by defining windows of opportunity as a phase of instability for the dominant, regime-level technology. Tongur and Engwall (2017) applied the windows framework to explore the barriers and enablers to infrastructure investments to support sustainability transitions. They added to the work of Nill and Kemp (2009) by defining four window-of-opportunity phases that enable niche innovations to become mainstream. These are the “pre-window-of-opportunity” state, the “opening” state, the “closure” state and “post-window-of-opportunity closing” state, described in detail below.

2.1. Four phases of the windows-of-opportunity

It is the “windows-of-opportunity” framework that we focus on in this study. In the “pre-window-of-opportunity state”, regime-level technologies are stabilised by lock-in effects. These include the deep relationship between major brands of products and supermarkets that create barriers for niche innovators. Niche innovations are in incubation stage and unable to gain a foothold due to the lock-in effects at the regime level and limited pressure on the regime to change from landscape factors (Tongur and Engwall, 2017).

In the “opening state”, the existing, regime-level technology is destabilised by external, landscape-level pressures. Such pressures include an increasing global awareness of climate change and incidences of pandemics such as the Spanish Flu, HIV/AIDS and Covid-19. Regime actors can become vulnerable to both emerging niche technologies gaining competitiveness, along with their own internal issues such as the unsustainability of their own technology. According to Tongur and Engwall (2017) in this state, newly emerged problems and solutions seek each other out and partnerships are formed between niche innovators and regime-level actors. Innovations are assessed and either modified to fit the existing regime or the innovation stretches the regime and transforms it to become the new socio-technical regime.

Covid-19 provided a recent example of an external, landscape factor threatening regime-level technologies globally with varying degrees of success and on-going durability. The pandemic prompted a volume of research in the past two years that applied the windows framework to understand niche – regime dynamics during this significant landscape-level shock. Dannenberg et al. (2020) describe the temporary impact of the pandemic on online grocery sales in Germany. Becker, von Schneidmesser et al. (2022) found that pop-up bicycling infrastructure established in Berlin during the pandemic is likely to remain in place, catalysing a regime shift from cars to bicycles due to the positive impacts that the infrastructure provides. Szasz et al. (2022) reviewed the impacts of Covid-19 on online retail in 23 countries. While the shock of the pandemic opened the “window-of-opportunity” for significant growth in online retail sales vis a vis regime level traditional retail stores, this was in the context of 10 years of slow and steady growth of online sales. In addition, multiple sub-regimes including shifts in policy (stricter government restrictions) and consumer behaviour (changes driven by reduced mobility) were identified as requirements to keep the window open ().

Sunio and Mateo-Babiano (2022) focused their research on transportation in Metro Manila. Prior to the pandemic, cycling was not a common mode of transport in the city due to safety concerns. Covid-19 opened a “window-of-opportunity” for the government to create a more sustainable transport system. They introduced policies that were supportive of cycling including business model development for operators, safety measures for cyclists along with the financing and implementation of bus routes and infrastructure supporting active mobility that continues today. These examples support the view of Normann (2015)

whose research on policy development related to the introduction and subsequent demise of wind farms in Norway. He suggested that windows of opportunity open not only when the dominant technology is under pressure but also through government interventions as they respond to external pressure. Kingdon (2013) also touched on the role of politics in niche-regime dynamics. Kingdon suggested that niche innovations have a far greater chance of becoming mainstream if the political stream is supportive of it. He adds that windows do not themselves deliver change, rather it is in combination with a specific niche-level solution that can effectively address a problem. Covid-19 provided a rich vein of research using the windows framework which when viewed through the four phases lens, and specifically the opening state phase offers valuable clues as to how sustainability transitions come about and how they can be sustained.

The “closure state” is achieved when the niche innovation has more effectively addressed the problem than the incumbent solution and replaces it. Lastly, in the “post window-of-opportunity closing state”, the socio-technical system has been reconfigured with the niche technology at the centre of the solution. The approach and insights from the existing research provides a fruitful foundation for this research paper. In this paper Tongur and Engwall (2017)’s four phases of the windows framework is adopted.

3. Methodology

The researchers selected the state of New South Wales (NSW) in Australia for the location of this study for three reasons. Firstly, the lead researcher is based in the state and his nappy industry background meant that he was able to identify key stakeholders more easily. Secondly, NSW recently announced a state-wide mandate for all councils to offer FOGO by 2030, signalling an innovative waste policy intent that could create a unique opportunity specific to compostable nappies. Lastly, the location is representative of a Global North context allowing for a level of generalisations about the findings to be made. Ethical considerations related to the lead researcher’s nappy industry background, and possible conflicts of interest were addressed in the following fashion. Because the lead researcher’s work in the nappy industry has been and will continue to be in markets outside Australia, impartiality could be maintained. In addition, his industry background was disclosed to all interviewees during the recruitment process.

For this study, we used two methodologies. We initially conducted semi-structured interviews with key stakeholders at both the niche and regime level in the nappy industry. During the interviews with the three niche actors, a small-scale pilot of a niche nappy innovation in rural NSW was described. This presented us with a case study that we could use to understand niche-regime dynamics more broadly.

3.1. Stakeholder identification

Stakeholders were identified by mapping each actor across the supply chain from the manufacturing of the product to the end-of-life management of its waste (Table 1).

At the niche level, the stakeholder mapping identified the compostable nappy company, niche waste management companies (industrial

composters) and councils (local government) willing to address plastic nappy waste in innovative ways.

At the regime level, this included major disposable baby nappy brands, national supermarkets, childcare centres, waste management companies and waste management regulators at local and state government levels. Major disposable nappy brands are the providers of the product that 95% of Australian parents use (Klein, 2018). National supermarkets are the key retailer and the choice of products they choose to stock influence what nappies parents use. Childcare centres were included as 47% of Australian children aged 0 - 5 attend childcare centres (Australian Government, 2021). As a result, childcare centres are a significant purchaser and consumer of baby nappies. Waste management companies are a key element of the nappy regime as they are charged with collecting and managing nappy waste. Waste regulators at the local and state level are responsible for regulating waste streams generated by households. This includes issuing licenses for landfill and compost operators to accept and process waste safely. It also includes the introduction of new waste management laws that directly impact how compostable products are managed at end of life.

The stakeholder mapping identified interviewees who we then approached to be interviewed. While the primary author’s commercial experience provided relevant industry knowledge for this research, major global nappy manufacturers who were approached for interviews were unwilling to be interviewed owing to the perceived potential commercial conflicts. Thus, this research does not include primary data providing the perspectives of major disposable nappy manufacturers. We have instead relied on secondary data through consumer research and industry association reports to address the gap in data (Dyer, 2005; Nonwovens Industry, 2017; EDANA, 2018). Table 2 below summarises the stakeholder interviewees.

3.2. Niche level case study

The niche innovation used in the case study was a nascent compostable nappy and service. The compostable product is delivered, collected and composted by the manufacturer or a third party to ensure no waste goes to landfill. For this innovation to displace the disposable nappy regime, a system change is required including regulatory reform to allow for the composting of human waste along with the establishment of commercial composting infrastructure and reverse logistics services. These elements add cost to an already relatively expensive product due to the more expensive compostable materials used in its design. Baby nappies are a highly price-sensitive category which impedes the commercial viability of such innovations. Because of these challenges, sustainability innovators focused on systems change have limited access to capital further restricting their ability to scale and threaten the regime. The compostable nappy and service provides a unique research subject. This is because it is pre-commercial in stage and faces several complex factors in order to threaten the regime.

Interviews with the three niche-level stakeholders revealed details of their collaboration in a small pilot using the niche compostable nappy in a rural community in New South Wales. This case study provided a

Table 1
Summary of Stakeholder Identification Process using the Multi-Level Perspective.

Niche Level	1 Compostable nappy & service innovator 2 Niche waste management companies 3 Forward-thinking councils
Regime Level	1 Disposable nappy brands 2 National supermarkets 3 Childcare centres 4 Waste management companies 5 Waste management regulators

Table 2
Summary of Stakeholders interviewees.

Niche Level	1 Director – niche compostable nappy & service innovator 2 Manager - commercial composting company 3 Waste strategist – rural-based council
Regime Level	1 Executive - national supermarket 2 Procurement Manager - for-profit childcare centre 3 Early Childhood Education Researcher - not-for-profit childcare centre 4 Waste Educator – Sydney council 5 Recycling Educator – Sydney council 6 Project Officer – state-based waste regulatory authority 7 Policy Officer – state government department

valuable source of data which revealed the elements necessary to open the “window-of-opportunity” to disrupt the stability of the nappy regime. The Waste Strategist at the rural-based council provided background information about the pilot. The council’s landfill was approaching capacity at a faster rate than initially expected. They also noted that a high proportion of organic waste was being disposed in the landfill. Faced with the prospect of raising a levy from the community to build a new landfill, the council chose to develop a commercial composting facility. This offered additional economic and environmental benefits which also contributed to the “window-of-opportunity” being opened. Economic benefits included extending the life of the current landfill which increased the return on the original investment of the existing landfill. The cost of establishing and operating a composting facility is less than a landfill according to the Waste Strategist at the council. In addition, while not significant, the compost generates some income as it can be sold back into the local community. The environmental benefits of commercial composting include a reduction in greenhouse gases associated with organics entering landfill and the resultant compost which benefits soil health (Liu et al., 2022). To encourage the community to divert their organic waste to composting, the council also provided a weekly, separate kerbside food organic and garden organic collection service (FOGO). This would divert organic waste away from landfill reducing greenhouse gas emissions by the landfill. It would also produce compost which could be used to support soil health in the community. To encourage separation of organic waste from residual waste and maximise the amount of organics diversion, the council reduced their existing weekly landfill-bound waste collection to every second week. This caused parents to complain that they were having significant amounts of dirty nappies accumulating in their bins between collections. Collaborating with the community, the council devised a one-month pilot of a niche, compostable nappy to address the problem.

3.3. Regime level semi-structured interviews

The lead researcher conducted semi-structured interviews with stakeholders in person or over zoom depending on the subject’s preference and availability. Recordings were transcribed and analysed using the NVivo software program. A coding framework was devised that organised the data in a consistent manner to identify key themes. Coding was conducted solely by the lead researcher. Each interview was coded to identify themes which were then analysed through the four phases of the windows of opportunity lens posited by Tongur and Engwall (2017). This approach enables the research to deliver the four research contributions, namely the unique application of MLP to nappies along with the application to a specific product category, understanding this specific niche-regime dynamic using the windows framework and identifying lessons from this research to understand how future windows of opportunity can remain open to accelerate sustainability transitions in the nappy industry.

4. Results and analysis

The results and analysis section is presented following the four states of the “windows-of-opportunity” framework (Tongur and Engwall, 2017) numbered (4.1) to (4.4) summarised in Table 3 below and expanded in the following section. For greater readability, the narrative and analysis are presented together.

4.1. Pre-window-of-opportunity state

4.1.1. Intense competition for young parents by supermarkets support regime stability

The case study and interviews highlighted the relative power dynamics across regime-level actors. It shows the limited possibilities of this particular niche nappy innovation becoming mainstream. In the

Table 3
Summary of results using Tongur and Engwall (2017)’s Windows-of-Opportunity framework.

(4.1) Pre-window-of-opportunity state	(4.2) Opening state	(4.3) Closure state	(4.4) Post-window-of-opportunity closing state
Stable Regime ... Long-term regime stability is evident, driven by consumer demand for the incumbent disposable nappy product enabled by two main stakeholders: supermarkets and childcare centres. Three factors that ensure nappy regime stability: 1 Low price 2 High performance 3 Convenience.	... the window opens ... Regime stability is threatened by a niche nappy innovation driven by two factors: 1 Demand for new, cost-effective waste management resulted in the introduction of industrial composting. 2 Introduction of weekly Food Organic Garden Organic (FOGO) waste collection to maximise organic waste diversion to compost facility lead parents to demand compostable nappies.	... the window closes ... The opportunity for the niche innovation to threaten the regime closes due to two: 1 The commercial composting facility reached capacity. 2 The regulator bans the biofilms that the niche nappy innovator uses to make the product as a feedstock in FOGO collection.	... regime stability returns. Incumbent disposable nappy usage returns.

“pre-window-of-opportunity” state, stability in the nappy regime is driven by the intense competitiveness between supermarkets to appeal to young parents. The Executive of a national supermarket who was interviewed for this research reported that where parents buy their nappies is typically where they do their entire weekly grocery shop.

“The shop that the customer buys their nappies in is a part of a big purchase, it is normally their main shop. And so the basket will also shift. There’s a real risk that we disappoint our customers. It is a product you need, and we may potentially lose customers and lose not just the nappy purchase, but also the entire basket as well”.

If a parent’s preferred nappy brand or size is unavailable, they will go elsewhere to buy not only their preferred brand of nappies but their entire weekly grocery shop. This phenomenon has significant financial repercussions for supermarkets, requiring them to prioritise satisfying the needs of young parents. According to the Executive, this dynamic is relatively unique to nappies. It makes the supermarket’s decisions around which nappies to stock and at what price far more important than many other product categories. Supermarkets are the main distributor of nappies to parents in Australia according to the Executive. As such, supermarkets play a key role in maintaining the stability of the regime based on the decisions they make about which nappies to sell. He added that convenience, performance and price drive a parent’s purchasing decision.

“And so things like cost and being able to sell a product and affordable price is very important to a lot of baby customers. Quality and fit, absorbency, irritation that is incredibly important”.

There is limited differentiation between the major brands of nappies with each offering similar levels of convenience and performance. This leaves price as the remaining factor in a parent’s decision about where they buy their nappies. This then leads supermarkets to price nappies aggressively to appeal to young parents.

The Executive also mentioned that nappies take up a significant amount of shelf space. An indicator of financial success for supermarkets is how “productive” the shelf is. A productive shelf in this case means a product which is bought regularly and therefore needs replenishing frequently. This indicates consistent sales for the supermarket and is something that they strive for. This suggests that for the stability of the nappy category to be threatened, a niche innovation would need to gain distribution in supermarkets by matching the convenience, performance, and price of current nappies to generate similar levels of productivity at the shelf. According to the Executive, a supermarket would not be willing to risk losing young parents if the new, niche innovation was unable to match the incumbent nappy’s productivity at the shelf.

An additional source of stability in the regime are childcare centres and their choice of nappies. According to the Department of Education, 47% of Australian children aged 0 – 5 attend childcare (Australian Government, 2021). Some childcare centres provide nappies for parents while others ask parents to provide nappies. The Procurement Manager for a for-profit childcare centre chain, serving 20,000 families purchases disposable nappies for all childcare centres. Reportedly, reusable nappies are not an option as they require more regular changes and there are health considerations storing soiled nappies onsite to be collected by parents each day.

“Researcher: So if I’m a parent, and I say “can I bring my cloth nappies in” would the centre say no?”

Procurement Manager: I think they probably would say no, because there’s also the clean-up issue where there might be a bit more of a mess. With that comes all sorts of other health issues”.

The Procurement Manager also reported that waste management systems at childcare centres are designed to efficiently manage soiled disposable nappies. Waste management companies are contracted to collect and dispose of this waste in landfills. A researcher at the largest not-for profit childcare chain in Australia with 65,000 children in their care, reported that the choice and provision of nappies is left up to each parent. The interviewee said that it was very much the parents and their preference for disposable nappies that needed to be respected:

“you’d be out of business very quickly, when it comes to caring for children, if you didn’t put the parents front and centre in terms of what they want.”

Parent preference for disposable nappies along with childcare centres and the waste management companies that service them create lock-in effects that contribute to the stability of the nappy regime.

4.2. Opening state

4.2.1. Case study: unique circumstances open the window and keep it open

Specific events or circumstances can provide triggers to opening windows of opportunity (Normann, 2015; Tongur and Engwall, 2017, Dannenberg et al., 2020, Becker et al., 2022, Szasz et al., 2022). Demand for cost-effective waste management opened the window-of-opportunity for the niche nappy innovator in a small, rural town in New South Wales. The Waste Strategist at the rural-based council described a unique combination of actors and circumstances that kept the window open for a period of time. These included a pro-active council looking for solutions, a rural setting, a tight-knit community, the provision of a niche nappy provided at no cost to parents and the role of the waste regulator. The council was particularly proactive in solving the nappy waste issue with the community:

“It’s not Council’s normal business to go down this pathway either, but it was just about saying ‘we’re here, our community, we’re going to try and actually fix this because someone has to resolve it’ ...”

The rural setting offered the physical space for an expansion of an existing industrial composting facility which isn’t typically available in

urban areas. The Waste Strategist explained that the tight-knit community had been brought together previously through bushfires and floods. It meant that they were willing to come together to solve the nappy waste problem that emerged from the introduction of FOGO. The niche nappy innovator also played a key role in keeping the window-of-opportunity open. They were willing to provide nappies at no cost to 50 families for the one-month pilot. They were also able to leverage the success of their existing partnership with another council’s FOGO program to attract the interest of this council.

The product has been included in another city’s FOGO collection for several years. After collecting the used product each week, the council composted the product, certified the material to Australian Standard AS4454 and sold it for \$75/m³. The nappy manufacturer reported that the appeal of this approach is that it leveraged the council’s existing FOGO collection and composting facilities at no incremental cost to the company or the parents. For the council, it provides a constant feedstock for its compost production that would otherwise be entering its landfill. For the rural-based council pilot, the nappies were delivered to participating households at no cost to the parents. Parents would deposit used nappies in their FOGO bin for weekly collection. The goal of the pilot was to gather user feedback on the product and test its compostability in the council’s composting facility. The Waste Strategist reported that the user feedback was positive and purchase intent was strong assuming the price premium wasn’t more than 10-15% of disposable nappies.

In order for used compostable nappies to be accepted into an industrial composting facility, testing of the compost is required and an assessment made by the waste regulator. Waste management facilities are regulated by the state authorities and their willingness to engage in the trial was of critical importance. The composting of human waste is not legal in industrial composting facilities in Australia. For the council to conduct the pilot they needed to know that if successful, they would be able to accept this compostable nappy waste as an on-going waste stream in their composting facility. This process involves independent laboratory testing of the compost to ensure it is free of pathogens and safe to apply to soils as a compost. The council were successful in their application process which permitted them to transition the pilot into an on-going service for its residents. For the niche innovator it meant an expansion of its business and validation of its product for other councils to potentially adopt. An additional factor that kept the ‘window-of-opportunity’ open came in August of 2022 when the NSW government announced the mandatory introduction of FOGO across the state to reduce landfill-bound food and organic waste by 50%. For the niche nappy innovator, this decision held the promise of more councils looking for proven compostable nappy solutions to address the same negative feedback the council in this study had experienced with parents as they grappled with the odorous waste generated by soiled nappies. This policy intervention effectively kept the window-of-opportunity open for an extended period. It allowed the niche nappy innovator to gain additional traction. The pilot achieved its goals and was regarded as a success by the council and the niche nappy manufacturer.

4.3. Closure state

4.3.1. Compost capacity and new regulations close the window

According to the Waste Strategist, the council’s FOGO program exceeded expectations and they have been able to divert 10% of their landfill-bound waste to compost. As a result their composting facility reached capacity and they were not able to offer the compostable nappy solution until a new facility is built. This effectively closed the window-of-opportunity for the niche nappy innovator. In addition, in September 2022, the waste regulator announced that the only waste streams allowed in FOGO was food waste and garden waste (Proust, 2022). This prevented the inclusion of the niche nappy despite the successful independent test results of the product in industrial composting facilities. This was driven by contamination concerns by the regulator. As the

Director of the niche nappy manufacturer stated, the pilot has:

“given us the opportunity to demonstrate to the EPA that this is a practical, simple and economical way of recycling compostable nappies. And they do recognise, they have admitted that that this is the right way to go. However, they’re not ready to support that across the board because they need the education to go with it”.

Unlike [Tongur and Engwall \(2017\)](#)’s case study that applied the “window-of-opportunity” framework, the niche innovation in this case was unable to destabilise the regime. In [Tongur and Engwall \(2017\)](#)’s case, the niche freeway infrastructure project was thwarted by regime-level responses from powerful stakeholders. In this case, it was in fact a lack of composting facility capacity initially and ultimately a ban on all non-food and non-garden waste materials in FOGO that closed the window. It is important to note the inherent limitations of the pilot, namely its small scale, the free product provided to parents and the exclusion of supermarket and childcare centres.

4.4. Post-window-of-opportunity closing state

With the pilot concluded due to industrial compost capacity limitations and new regulations, the “post-window-of-opportunity closing state” was entered. Parents returned to using disposable nappies with used product being collected in the fortnightly collection and landfilled as had been the case prior to the pilot.

4.5. Additional barriers: price, performance and convenience

Beyond the limited scope of the case study above, the niche nappy innovator faces additional barriers more broadly to destabilise regime-level actors. Achieving price parity and matching performance and convenience of disposable nappies are the most significant of these factors. According to the Executive at the national supermarket, a new nappy offering will only get mass appeal if they are offered at a competitive price and with the same convenience and efficacy as current disposable nappies. For niche sustainability innovators, achieving price parity and matched convenience with incumbent products is a very difficult task. One example of this is reusable nappies. The Executive of the national retailer mentioned that the high price of reusable nappies, a niche product with just 5% market share ([Klein, 2018](#)) has prevented the retailer from offering them nationally at the supermarket:

“Reusable nappies isn’t (sic) something historically we’ve sold. Typically, they’ve got a much higher price point and it’s a fairly niche market, and so wouldn’t be suitable ranging everywhere.”

Plant-based milk faced similar challenges in the early stages of their development before lower cost was achieved through technological advances ([Mylan et al., 2019](#)). The niche nappy innovator is attempting to develop a compostable nappy using materials that need to compete on price and performance with plastic. As a by-product of oil production, plastic is consistently one of the lowest priced raw materials available. This is a significant challenge.

The Procurement Officer at the for-profit childcare chain – while expressing an intent to offer more environmentally sustainable nappies for their families – cost, convenience and efficacy were of primary importance. This along with concerns about how to integrate a dedicated composting collection for the nappies meant that they were unlikely to consider this innovation. In the interview with the urban-based council waste educator who pioneered FOGO, there was immediate resistance to the introduction of any non-food or non-garden organic material in their program. This was prior to the waste regulator’s ban on such material being included in FOGO. The key reason was the risk of contamination. The council’s current rate of contamination is less than 2% and any introduction of a compostable product poses contamination risk if a similar product made from non-compostable materials enters FOGO. Excessive contamination rates trigger penalties to be paid by the

council to the waste management company. This points to the need for consumer education if compostable products are to be successfully introduced into FOGO.

The findings set out above show that the disposable nappy regime is a stable one. This is due to powerful stakeholders including supermarkets and childcare centres who promote disposable nappies to support the success of their own businesses. Supermarkets mediate between the manufacturer and the consumer and require any new entrant to match the price, performance and convenience levels of the incumbent disposable nappy. This is also the case for those childcare centres who provide nappies for the babies in their care. A third stakeholder, waste management companies offer additional regime stability as their service is designed to efficiently collect and manage used nappies in landfills. The window of opportunity only opened for the niche nappy innovator as a result of two preceding concerns. The first was to address landfill capacity constraints which led to the development of an industrial composting facility. The second was the introduction of FOGO which then led to parents asking the council for a solution to their disposable nappy waste issues. The window stayed open due to the commitment of multiple stakeholders searching for a solution. The window closed initially due to capacity constraints at the industrial composting facility and ultimately with a state-wide ban on the inclusion of compostable biofilms in FOGO programs ([Proust, 2022](#)). Compostable biofilms are an important ingredient in the niche nappy innovator’s nappy. [Fig. 1](#) below summarises these dynamics.

5. Discussion

5.1. A stable regime in the nappy industry

This research showed a stable regime in the nappy industry. The regime includes the large supermarkets serving as the key distributor of the product, childcare centres which are used by almost half of all babies and waste management companies. [Mylan et al. \(2019\)](#)’s application of MLP to the liquid dairy milk industry also revealed a stable regime, at least initially. That regime includes farmers, supermarkets, coffee shop chains, state-sponsored nutritional agencies and agricultural lobbies. Unlike the relatively new niche nappy studied here, plant-based milks (PBM) have the advantage of 50 years of development. With a growing awareness of the health and environmental issues with liquid dairy milk, PBMs have ultimately destabilised the regime and entered the mainstream market. It started as a niche, featuring small, independent manufacturers serving the few who had ethical concerns about liquid dairy milk or medical issues associated with consuming dairy milk. In the mid 2000’s consumer interest in PBM’s grew thanks to technology that lowered cost and an improved flavour that more closely resembled liquid dairy milk. It was price and performance that drove the popularity of PBM and enabled it to destabilise the regime. It now has a global market share of 12% ([Mylan et al., 2019](#)). The regime, sensing the genuine consumer demand that could provide them additional revenue streams, engaged and embraced the niche by either acquiring independent brands or developing their own brands. A crucial step in the mainstreaming process was the supermarket’s decision to place PBM’s in the refrigerated dairy cabinet, next to liquid dairy milk. The niche nappy innovation used in this research has not had the benefit of 50 years of product development that may have reduced price and increased performance to match incumbent disposable nappies. There has also been a relatively low level of awareness about the environmental concerns of disposable nappies that may have caused parents to demand alternatives. For this research we were unable to interview either of the two large global nappy manufacturers, however the powerful influence of supermarkets and childcare centres was evident in our primary data. Neither are willing to offer niche compostable nappies given the price, performance and convenience discrepancies with incumbent disposable nappies. As a result, the niche nappy innovation remains a niche, unable to attract mainstream distribution.

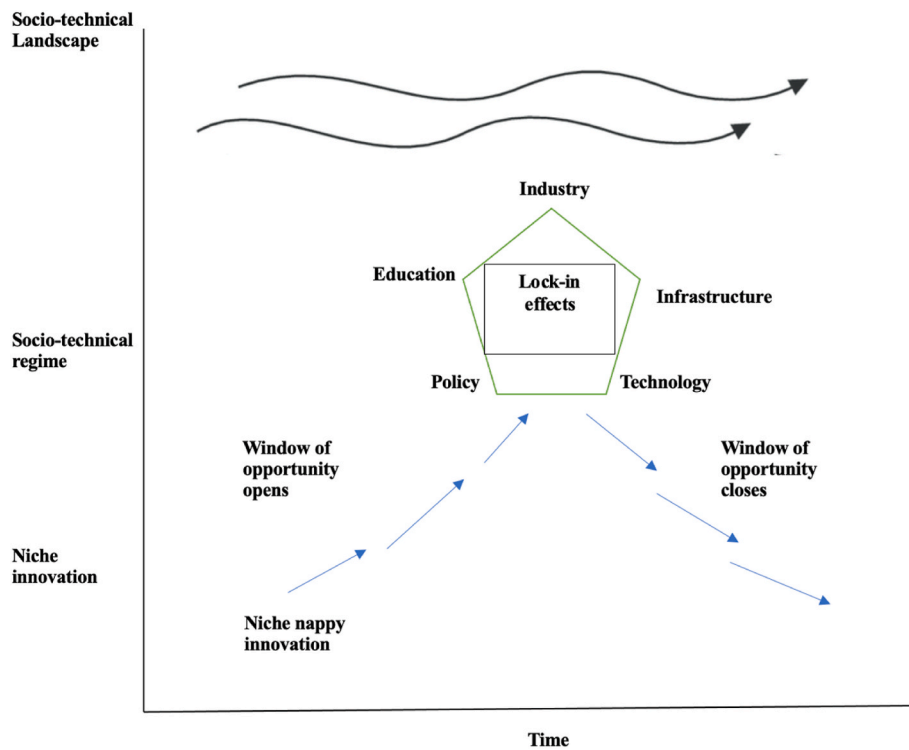


Fig. 1. Adapted from Geels (2002).

Greater awareness of the environmental issues that disposable nappies cause may serve as a precursor to what Mylan et al. (2019) referred to as “Rage and Reform”. For PBMs this phenomenon saw the regime destabilised following a growing trend for healthy and more environmentally friendly alternatives over decades, a sufficient amount of demand from consumers forced the regime to reform and include PBMs in their offerings.

PBMs benefitted from offering two different user motivations to pressure regime change, one health, the other environmental. This by definition increases the number of people seeking change. A change in nappies however isn’t influenced by the health factors that have driven the mainstreaming of PBM’s. This leaves just environmental concerns as a main factor. Nappies are a necessity for parents in a period of particular exhaustion for them as they adjust to the first 3 years of their child’s life (Gillis and Roskam, 2019). While a proportion of parents may be aware of the environmental issues of disposable nappies, an insufficient number are demanding alternatives to threaten the regime. There was no evidence of a “rage” against the nappy regime by parents to effect reform at the regime level (Mylan et al., 2019). As a result the niche nappy innovator was unable to threaten the regime. Unlike PBM, there is limited evidence of any health concerns caused by disposable nappies, rendering a second driver for alternatives unavailable to niche nappy innovators. In the pilot study featured in this research, we found that disposable nappy waste was a third order concern after the council had addressed their landfill issues and introduced FOGO. It may take a longer period of time for awareness to grow about the disposable nappy waste issue to prompt parents to demand alternatives as was the case with PBMs.

A multi-stakeholder approach may hold the key for niche nappy innovators to threaten the regime. This approach emerged as a common, supportive feature for both PBM and compostable nappies as they attempted to threaten the regime. For PBMs, this included niche manufacturers, consumers, supermarkets and coffee shop chains. NGOs also played a role in changing the cultural significance of dairy milk consumption by criticising dairy milk producers about their product claims (Mylan et al., 2019). In the case of the niche nappy innovator in the

pilot, a similar phenomenon occurred on a much smaller scale. A council, a community and a waste regulator came together to solve a series of problems, one of which was disposable nappy waste. A possible future enabler for niche nappy innovators is a multi-stakeholder approach.

Morris et al. (2014) applied MLP to understand how less meat initiatives (LMIs) may or may not threaten the meat regime. LMIs are an example of a social innovation to reduce meat consumption rather than a product innovation that this paper focuses on. Examples of LMIs included campaigns such as Meat-Free Mondays and Meatless Mondays in the US and UK. The researchers found that while LMIs did increase awareness about the issue, a move to eating less meat was too radical to threaten the regime and become mainstream. Regime-level actors, namely media organisations and interventions by governments including subsidies, proactively promoted diets with a high meat component. This contradicted the efforts of LMIs. These actions by regime-level actors in the meat industry proved to be too strong to be threatened by LMIs. A similar phenomenon can be observed by the regime in the nappy industry. When the environmental concerns about disposable nappies first emerged in the early 1990’s, the US government considered a tax on disposable nappies. This would have encouraged the use of reusable nappies which had been a niche offering for the preceding 40 years. In response, disposable nappy manufacturers launched a campaign to convince users and lawmakers that disposable nappies were compostable in 90 days and posed no environmental damage (Kinney, 1990). This campaign was supplemented by industry-paid research by Arthur D. Little (Rockney et al., 1991). The advertisement (Fig. 2) was deemed to be deceptive by the Fair Trade Commission (Baker, 1998). Over the proceeding ten years the 400 reusable nappy companies operating in the US were reduced to just 50 (Baker, 1998). While many factors may have caused such a decline the regime’s response to the proposed ban was a likely factor. The disposable nappy market share grew to 85% during this period (Rockney et al., 1991) and by 2020 it has reached up to 95% in most developed economies (Olivo, 2005). Like reusable nappies before them, the compostable niche nappy innovation faces significant resistance from the regime.



Fig. 2. A 1991 Procter & Gamble advertisement in the New York Times in response to a proposed tax on disposable nappies.

5.2. The role of government in levelling the playing field for niche nappy innovators

Government intervention can play a key role in keeping the window of opportunity open to allow niche nappy innovators to gain a foothold. The window-of-opportunity framework was applied in a series of papers during the Covid-19 pandemic (Dannenberg et al., 2020; Becker et al., 2022; Sunio and Mateo-Babiano, 2022; Szasz et al., 2022). Covid-19 served as a large, landscape-level shock that triggered the opening of a multitude of windows of opportunity. This included transport in Metro Manila, bicycling in Berlin and e-tailing in Germany. In the case of Metro Manila and Berlin, the size of the shock was sufficient enough to destabilise the regime for niche bicycling to become mainstream.

In contrast, in this research for the nappy regime, the shock was barely perceptible given the nappy waste problem was a second-degree concern from parents after FOGO was introduced in a small, rural community. Similarities exist between the case studies used in prior windows of opportunity research and this paper. It is clear that government intervention is effective at forcing the window open and allowing niche innovations to enter the regime. This can be seen in the Metro Manila and Berlin bicycling cases. Similarly the government's state-wide mandate for all councils to offer FOGO by 2030 is having a similar effect in promoting industrial composting as an end-of-life solution. A reconsideration of the ban on compostable biofilms as an acceptable waste stream in FOGO by the waste regulator might again open the window-of-opportunity for the niche nappy innovator and provide a potential pathway to mainstream adoption. There are limitations to the effectiveness of government interventions. In 2022, the UK Government introduced a Plastic Packaging Tax at a rate of £210.82/tonne on plastic packaging with less than 30% recycled plastic (PWC, 2022). While a similar policy for non-packaging plastic could be

considered, the suggestion of a tax on the plastic in nappies made by the then UK Minister for Environment, Michael Gove was quickly denied, after it was depicted as a tax on parenting (Blewett, 2021).

6. Conclusion

This paper addressed the power dynamics in the disposable nappy regime and opportunities for niche innovations to gain traction in the industry. This study found a series of factors that prevented the niche nappy innovation from threatening the regime. These included the strength of regime actors, the compostable nappy technology's inability to compete with the incumbent on performance, convenience and price and low levels of awareness around waste management issues. To address these issues, government interventions are necessary. These include policies that allow biofilms that have been approved to be industrially composted to be included in the FOGO program. This paper identified several insights about how windows of opportunity can occur, what factors keep the window open and what causes the window to close in the context of baby nappies. These findings are significant as they can help guide the decisions of all stakeholders, from policy makers to nappy manufacturers, retailers, childcare centres and waste management companies if they choose to address the inherent waste generated by disposable nappies. This paper makes four theoretical contributions to sustainability transitions literature. It applied MLP to a specific product rather than a system and did so in the nappy category for the first time. It tested and confirmed the "windows of opportunity" framework developed by Tongur and Engwall (2017) and suggested how future windows of opportunity can remain open to accelerate sustainability transitions in the nappy industry. The study was limited in a number of ways. The case study was small in scale, located in a rural setting and featured a unique set of actors namely a committed local council, and a community with particularly strong bonds from which generalisations are difficult to make. The case study was also incidental to the research meaning it emerged during interviews rather than being intentionally designed by the research group from the outset. The lack of participation by a major regime level nappy manufacturer also limited the study. As a result, a number of future research possibilities emerged from this study. Conducting a larger scale case study in an urban setting could provide rich insights to better understand the dynamics in the industry in a broader context. Having a major nappy manufacturer agree to participate in such a study would also make a valuable contribution. Another possibility would be applying the windows framework to other consumer product categories that create proportionately large amounts of waste and where innovation has been unable to threaten the regime. This study showed that lock-in effects across key stakeholders in the nappy regime has created a stable disposable nappy industry perpetuating plastic nappy waste problem. However, the introduction of policy interventions could open the window of opportunity for niche compostable nappy innovations to threaten the regime. In doing so, the plastic nappy waste crisis can be addressed with the on-going production of high quality, certified, marketable compost turning a costly waste into a valuable resource.

CRedit authorship contribution statement

Jason Graham-Nye: Conceptualization, Formal analysis, Investigation, Methodology, Resources, Software, Validation, Visualization, Writing – original draft. **Nick Florin:** Supervision. **Monique Retamal:** Supervision.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Jason Graham-Nye reports a relationship with Kuver Designs Pty Ltd that includes: consulting or advisory. Jason Graham-Nye has patent with

royalties paid to Down to Earth Designs Ltd. To clarify the earlier disclosure, I am a Director of "Down to Earth Designs, Ltd", a US company that has been the licensee of a patent for a compostable baby diaper designed and patented by Sue Allison-Rogers of Kuver Designs Pty Ltd. Down to Earth Designs, Ltd owns the rights to the patents of the baby diaper outside of Australia and New Zealand. The case study referred to in this research used this compostable baby diaper. As this research has been conducted in Australia, the lead author derives no financial benefit from any outcomes from the research. In addition, I do not own the patent nor have I ever received payment from Kuver Designs. The Declaration of Interest form didn't have a selection that reflected the above circumstances but a box needed to be checked to proceed.

Data availability

Data will be made available on request.

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