

The Journey from Consumer to Investor: Designing a Financial AI Companion for Young Adults to Help With Sustainable Shopping, Saving, and Investing

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The Journey from Consumer to Investor: Designing a Financial AI Companion for Young Adults to Help With Sustainable Shopping, Saving, and Investing

從消費者到投資者的旅程：為年輕成人設計一個財務人工智能夥伴，幫助他們進行可持續購物、儲蓄和投資

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NCKU

Abstract

Taiwanese college students are concerned with environmental issues, yet they are hindered by lack of simple tools to affect systemic change. Meanwhile, on the other side of the Planet, strengthening environmental policy from the European Union includes the concept of *digital product passports*, which aims to help distinguish *eco-designed* products made by *circular economy* companies striving to be zero-waste from companies that simply engage in *greenwashing*. Tracking product data from the source materials until the consumer purchase and finally post-purchase recycling, combined with *data-driven interaction design* facilitates building transparency into opaque global supply chains by using *large-language models* and *artificial intelligence assistants* to translate complex environmental data into human-comprehensible language.

The emerging field of *planetary health* recognizes profound interconnections between our economic behaviors, ecosystem services such as clean water, air, soil, the climate crisis, and human health. As of 2024, Earth's natural environment is being heavily degraded by the extractive business practices of companies that make many of the products and services we buy every day. The way we use our money to interact with companies - through shopping as consumers and saving / investing as investors - has an effect on the life-supporting biosphere we rely on to keep our planet inhabitable. In essence, from an ecological perspective, every financial action is either an investment decision to support more environmentally-friendly companies - or to support polluters.

My research addresses the need for tools to make sustainable financial action more convenient, focusing in particular on college students. I leverage *design research* to find design concepts for *simple AI-based user interfaces* also known as *generative UIs* to help young adults participate in *sustainable financial activism*. A survey of 700 students across 10 universities in Taiwan was conducted, enhanced by 5 expert interviews providing industry insights. The major contribution of the study is an interactive AI-assistant prototype.

ADD: Democratization of Financial Markets

Keywords: Climate Anxiety, Planetary Health, Human-AI Interaction, Digital Sustainability, Financial Activism, Transparency

摘要

大學生關注環境問題，但因學業繁忙及缺乏簡便工具來影響體制改變而受阻。歐盟更強化環保政策，引入了「數位產品護照」的概念，此舉有望幫助區分由循環經濟公司製造的、努力實現零廢棄的「生態設計」產品，與僅聲稱自己環保的公司。從原材料到消費者的產品數據追蹤，結合「數據驅動的互動設計」，有助於為不透明系統建立透明度。同樣地，「大型語言模型」的發展使得「人工智能助理」能夠成為複雜環境數據與人類可理解語言之間的翻譯層。

新興的「地球健康」領域認識到我們的經濟行為、生態系統服務（如淨水、空氣、土壤）、氣候危機與人類健康之間存在深刻的相互聯繫。截至 2024 年，地球的自然環境正被開採性企業的商業行為嚴重破壞，這些企業生產我們每天購買的許多產品和服務。我們通過消費和儲蓄/投資與公司的互動方式，對我們賴以生存的、支持地球可居住生物圈產生影響。從生態學的角度看，每一個財務行動都是支持更環保公司的投資決策，或是支持污染者。

我的研究應對了為大學生提供便於實行可持續財務行動的工具需求。我專注於利用「設計研究」來尋找「簡易 AI 用戶介面」的設計概念，也稱為「生成 UI」，以幫助大學生參與「可持續財務行動主義」。在台灣 10 所大學進行了一項涵蓋 700 名學生的調查，並增加了 5 位專家訪談以提供行業見解。研究的主要貢獻是一個互動 AI 助理原型。

關鍵詞：氣候焦慮、人工智能互動、數位可持續性、財務行動主義、透明度、地球健康。

The abstract was translated on May 22, 2024 using the Claude 3 Opus model. Translation quality was checked with OpenAI GPT4, Google Gemini, Mistral Large, Meta Llama as well as human reviewers. In case of any discrepancies, please refer to the English text.

Introduction

How can college students find sustainable companies? Furthermore, if given appropriate tools, could college students leverage their purchasing power to reward sustainable companies?

My research describes the process of designing an AI companion for college students to help with sustainable shopping, saving, and investing.

Money spent shopping, saving, and investing in sustainable companies serves as an incentive to adopt more sustainable practices. If used wisely, money can reward companies for becoming more sustainable.

Encourage the least sustainable companies to improve their performance, raising the overall baseline.

Facilitate the formation of communities centered around environmental stewardship.

Build closer relationships with sustainability.

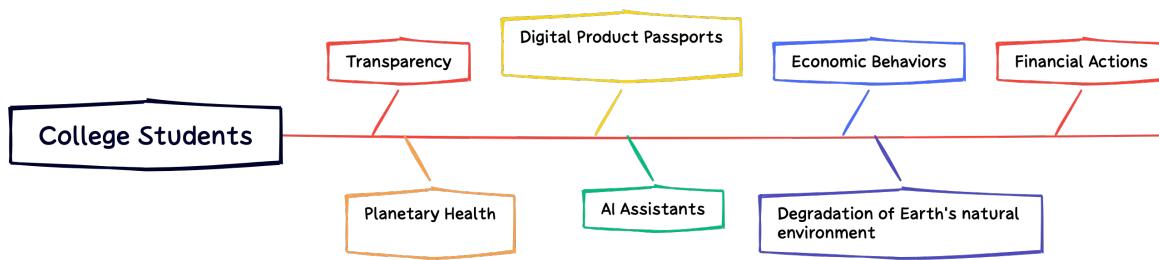


Figure 1: College Students

Relevance

The research addresses the “*attitude-behavior gap*” among Taiwanese college students in taking sustainable financial action.

Convergence of the following 5 trends makes my research timely in 2024.

Table 1: Trending narratives.

Trend	Direction
Environmental degradation	Worsening
Interest in sustainability among young people	?
Intergenerational money transfer; in some countries relatively young people have money	?

Trend	Direction
Availability of sustainability tools such as ESG, B Corporations, Green Bonds, etc, among metrics and instruments	Increasing
Availability of generative AI-based user interfaces (UIs)	Increasing
Democratization of Financial Markets	Increasing

Background

I grew up as an avid science fiction reader, which influenced my outlook towards future possibilities. In particular, the Star Trek universe had an imaginary portable device called a *tricorder* (fig. 1) enabling scientists to scan anything for insights. Be it precious minerals inside a cave or scanning the human bodies for medical data, its sensors would show up with some useful data. In daily life, I would love to have such a device for consumer choices and financial decisions - to know what to buy and which businesses to support with my money and approval.



Figure 2: Captain Sulu using a Tricorder (Star Trek) - Photo copyright by Paramount Pictures

While a *tricorder* is still science fiction, technological advancements are getting closer and closer to producing something similar. AIs are already integral to many parts of our lives, with computer models producing increasingly useful outputs. The proposal for this thesis was first written using Google's and Apple's voice recognition software in 2020, and later switching to OpenAI's *Whisper* model, allowing me to transcribe notes with the help of an AI assistant. As a foreigner living in Taiwan since 2019, I relied on AI-based tools for many aspects of my life: speaking, moving, finding food and services. When writing in Chinese, Apple's text prediction algorithms translate pinyin to 漢字 and show the most likely character based on my previous writing, Google's maps find efficient and eco-friendly routes and recommend places to eat and ChatGPT provides statistically probable advice from the sum of human knowledge. Even when we don't realize it, AI is helping us with many mundane tasks. While it takes incredibly complex computational algorithms to achieve all this in the background, it's become so commonplace, we don't even think about it. From this point

of view, another AI assistant to help students with choosing more eco-friendly businesses - to shop, save, and invest - doesn't sound so much of a stretch.

Motivation

Environmental degradation is increasingly affecting human lives - and it's largely driven by manufacturing processes - of the products we consume daily. From resource extraction in the linear economy (mining raw materials and drilling for fossil fuels) to chemical processes (causing contamination and pollution of the air, water, and soil) to waste generation and greenhouse gas emissions, industries transform the natural world into consumer products. While industry practices have improved since the industrial revolution in the 19th century, and continue to improve, it's possible to further improve standards of production and raise the global baseline for sustainability, given enough societal pressure to do so.

Nonetheless, without easily accessible and reliable data, it's difficult to know which company is more sustainable than another. As consumers and investors (even if only through passive ownership of savings), we don't really know much about enterprise production practices, unless we spend a lot of time looking at the numbers, which may be costly to access (for example ESG reports are expensive), and mostly rely on our governments and international bodies to keep us safe. Or just look at the brands themselves - and pick the ones which we like.

Objective

The study presents design research for developing an AI companion to help college students find sustainable companies for shopping, saving and investing. The major contribution of my study is an interactive artefact (a prototype) informed by design research.

Demographics

The research focuses on young adults, specifically Taiwanese college students studying in Taiwan.

Criteria	
Location	Taiwan
Population	College Students
Count	700

Experts (finance, design, sustainability).

Criteria	
Location	Global
Population	Experts
Count	5

Research Questions

My research answers the following questions.

Table 4: RQs.

Question	Methods
How could an AI companion integrate scientific knowledge in sustainability, design, and finance to support college students?	Literature Review
How could an AI companion help college students allocate capital to sustainable companies when shopping, saving, and investing?	Literature Review and Expert Interviews
How do college students prioritize AI companion features?	Survey of College Students

Literature Review

Scientific papers from ScienceDirect, Nature, the Lancet, Oxford Academic. There is currently no single platform that hosts all scientific journals, even though JSTor comes close?

The literature review branched out to 5 main directions and maps out relationships Sources and Literature Map:

- Taiwanese college students, generation-z demographics,
- Sustainability, ecology, ecosystem services, EU legislation.
- Sustainable finance, sustainable investing, savings, circular economy, economics.
- AI, review of existing software. Review of Mobile apps (Apple iOS / Google Android) and web app related to Sustainable shopping apps, savings, and investing and Apps using algorithmic interfaces (AI-based UI).
- Design, UX/UI, service design, sustainable design, speculative design, interaction design, behavior change, nudge.

Given the goal of designing an app to integrate shopping, saving, and investing sustainably. The goal of the literature review is to find ideas of app features. In order to keep track more easily, each literature review section includes **design implications** in context.

College Students

Student Protests Around the World and The Attitude-Behavior Gap

In August 2018, Swedish high-school student Greta Thunberg skipped class to start a climate strike in front of the Swedish parliament Riksdag. Millions of people around the world joined her *Fridays for Future* protests. Time magazine named Thunberg person of the year for *creating a global attitudinal shift* (Deutsche Welle, 2019).

- (Park & Lin, 2020) positive attitude towards sustainable products does not result in purchase decisions, shows research of fashion in South Korea. In one Australian study, green consumers still waste food similarly to the baseline (McCarthy & Liu, 2017).
- Munro, Kapitan & Wooliscroft (2023) shoppers trying to shop sustainably often fail to find sustainable products.
- Marc Lien (2022) Four millions British SMEs have no plan for net-zero transition.
- Ware (2024) British workers lack skills for green transition. (2024 National Environmental Services Survey)

Taiwanese Education System and Policy Environment

Taiwan has X young adults and Y percent of them are students.

Taiwan has an aging population (Goh et al., 2023). Taiwanese culture is influenced by Confucianism and Daoism, which affect education to be *teacher-centered*, where traditionally the role of students is to listen and absorb knowledge; there are open opportunities to revisit *dialogue-based* education, where students would be encouraged to take a more active role and gain ownership of their education (Chang, Wegerif & Hennessy, 2023). In general, teachers have a positive attitude towards sustainability. Taiwanese government launched the Sustainable Council in 1997 to promote of environmental and sustainable development; a survey of university-level teachers (n=100) in central Taiwan (Taichung, Changhua, and Yunlin) shows a positive attitude toward environmental sustainability among teachers however implementation of environmental sustainability practices is from low to medium range (林 & 莊, 2015). Elementary-school teachers in Taichung (n=536), have positive attitudes towards environmental education are positive, proactive and demonstrate high awareness; they have participated in many sustainability-related workshops (Liao et al., 2022).

At the pre-university level, Taiwanese government has been promoting environmental education through a green school network; however surveys at middle school and high school level suggest there is no impact on *sustainability consciousness* among students in comparison with regular schools (Olsson et al., 2019). Rather, Taiwanese students are influenced towards environmental action by *group consciousness* (Yu, Yu & Chao, 2017). In contrast, (陳珮英, 2003) reports *good knowledge of sustainable development* topics among *junior high school students* in Da-an District, Taipei City (n=596). (林, 2009) similarly reports a positive attitude and good knowledge of environmental sustainable development among senior *high school students* towards in Taipei City (n=328). Several Taiwanese studies also focus on the physical environment of school campuses, for example the sustainability of elementary school campuses (潘智謙 & Chih-Chien, 2006).

Taiwanese government has also launched funding for University Social Responsibility (USR) programs to train college students in social innovation and local revitalization (Chen & Chou, 2023; Liu et al., 2022).

I found less research on the university level. (Chen & Tsai, 2016) reports a *positive attitude yet moderate knowledge* about *ocean sustainability* among Taiwanese college students (n=825). (Liu et al., 2023a) studied sustainability behavior of Taiwanese University students, reporting the COVID-19 pandemic, in addition to prevalence of health issues, also spurred more attention on environmental topics. In a similar vein, the devastating nuclear disaster in Fukushima, Japan, after 2011 earthquake, had an effect on Taiwanese energy and sustainability education (姚 & 侯, 2011).

An older study in 5 university in Taipei and Taichung (n=255) found 78.04% of respondents consumed beef in the month prior and were concerned with food safety, freshness, and quality (Hsu, Lu & Chen, 2014). (Thiagarajah & Kay, 2017) reports a general observation in their abstract (I was unable to access the full study) that most college students in all observed countries including Taiwan (n=534) regarded “*plant-based diets to have health benefits*”.

Comparing college students' education for sustainable development (ESD) in Taiwan (n=617) and Sweden (n=583) found Sweden has a long history in environmental education while in Taiwan environment became a focus area with the 1998 educational reform (Berglund et al., 2020).

- The current environmental upheaval, led by Gen-Z and Millennials, and the business adaptation (or lack thereof) to sustainable economic models, taking into account the hidden social and environmental costs we didn't calculate in our pricing before.
- We also need to consider environmental effects (E in ESG). We haven't taken into account the whole cost of production, leading to the wrong pricing information. To achieve this, we need expert governance (G).
- I was unable to find similar research on university and post-graduate level students in Taiwan.
- Taiwanese college students and SDGs (Ho et al., 2022).
- College students in tourism and related fields . and sustainability
- Consumers may be turned off by mentioning AI in product description. Cicek, Gursoy & Lu (2024)

Climate Change Effect on Taiwan

Taiwan has been affected by drought over 4 decades, rising temperatures and altered rainfall patterns, impacting water security and semiconductor manufacturing(Vo & Liou, 2024). Corals surrounding Taiwan are affected by marine heatwaves, ocean acidification and increased sea surface temperature affects coral bleaching level (Hsu et al., 2024). Biomarkers in the sediment core around Taiwan are being used to study variations in climate over past thousands of years (Wang et al., 2021). Taiwan is affected by Kuroshio (黑潮) like Estonia is affected by the Gulf Stream. Both oceanic currents help regulate the climates of their respective regions and marine ecosystems. Kuroshio is a warm current of the Pacific Ocean. Rossby planetary waves driven by the Earth's rotation are crucial to keeping the atmosphere in balance by helping transfer tropical heat towards Earth's poles and cold air toward the tropics; interactions between oceanic currents, Rossby waves and nonlinear *mesoscale eddies*, which form complex undulations, and their effect on the climate are still not well understood (US Department of Commerce, n.d.; Belonenko, Sandalyuk & Gnevyshev, 2023; Liu et al., 2024; Lin et al., 2022b; Yin, Lin & Hou, 2019; Mensah et al., 2014; Shen et al., 2014). Around

33% of Taiwanese CO₂e emissions is captured by the marine carbon sink, while the effect of forests in Taiwan needs further study (Hung et al., 2024).

Sustainability Tools in the Taiwanese Context

Musical garbage truck are a success story of the environmental progress in Taiwan (Helen Davidson & Chi Hui Lin, 2022). Indeed, they are a *user interface innovation* and the main way how people in Taiwan interact with sustainability issues.

The popular narrative about Taiwan recounts the story of the economic and environmental transformation of the country. In the late 1980s during the heights of an economic boom Taiwan became famous as the Taiwanese Miracle (臺灣奇蹟) (Gold, 1986; Tsai, 1999). By the early 1990s another less flattering nickname appeared: “garbage island”, for the piles of trash covering the streets and overflowing landfills (Rapid Transitions Alliance, 2019; Ngo, 2020). In the two decades that followed, from 1998 to 2018, Taiwan made progress in municipal waste management, rising to the status of a world-leader in recycling (2nd *effective recycling rate* after Germany); in addition to an effective recycling system, the average waste amount generated per person by 700g (from 1140g to 400g) per day; nonetheless, industrial recycling rates were less stellar, standing at 80% in 2020 and there were unrealized opportunities in using industry 4.0 technologies, such as internet of things (IoT) sensors for better waste tracking (Wu, Hu & Ni, 2021; Bui et al., 2023).

Progress in sustainability is possible but achieving results takes time and innovation. (Rapid Transitions Alliance, 2019) credits the Taiwanese Homemakers United Foundation (財團法人主婦聯盟環境保護基金會) for initiating the transformation in 1987, suggesting a small group of people can have an outsized impact on the whole country. Their activity didn't stop there and (財團法人主婦聯盟環境保護基金會, 2020) recounts a timeline of their achievements on their website until the present day.

- Progress in other areas of environmental protection has not made similar progress.
- There are documentaries about oil product
- Plastic production documentary
- I've seen several.. find and cite them to show the progression of the environmental movement in Taiwan ADD CITATION
- The Taiwanese Green party
- Contact SOAS?

Taiwanese Companies and Online Shopping

Between 1970 and 2019 CO₂ was a prerequisite of economic growth in Taiwan (check this again) (Chang et al., 2023). Taiwan is a net CO₂ exporter since 1990s through emissions embedded in the industrial production oriented economy (Huang, Lv & Li, 2020).

TIME Magazine and Statista collaborative “*World’s Most Sustainable Companies Of 2024*” includes 17 Taiwanese companies (Alana Semuels, 2024).

Table 5: Data from (Alana Semuels, 2024).

Rank	Company	Score
24	Delta Electronics	77.18
63	Taishin Holdings	73.50
68	Fubon Financial	73.01
80	Chunghwa Telecom	71.69
91	Yuanta Financial Holdings	70.94
92	Cathay Financial Holdings	70.79
108	Taiwan Mobile	69.72
200	First Financial Holding	64.17
300	Far EasTone	60.04
301	SinoPac Holdings	60.04
344	Wistron	58.44
356	Acer	58.02
395	Nanya Technology	56.35
409	InnoLux	55.82
416	Wiwynn	55.67
421	Taiwan Cement	55.49
497	Advantech	53.14

- In Online Shopping, (聯合新聞網, 2024 predicts Momo and Coupang will compete for Taiwanese market leadership).

Global Data

- (Manchanda et al., 2023) survey (n=726) administered at shopping malls in New Delhi, India, found similar levels of sustainability consciousness between Millenial (n=206) and Generation-Z (n=360) age groups; people with high level of materialism were found to be less sustainability-conscious; the effect of mindfulness on sustainability was found to be stronger among females than males, supporting the hypothesis of the moderating effect of gender.

There's evidence young people have money. In the United States, the combined annual consumer spending of Gen-Z and Millennials was over 2.5 Trillion USD in 2020 (YPulse, 2020). Over the decade from 2020 to 2030, in the U.S., UK, and Australia, Millennials are projected to inherit 30 trillion USD from their parents (Calastone, 2020). There's also some evidence of investment interest, however there's large geographic variance. According to a (Calastone, 2020) study (n=3000) surveying people in the millennial age group between ages 23 and 35 in Europe (UK, France, Germany), U.S.A., Hong Kong, and Australia, 48% of respondents located in Hong Kong owned financial securities (such as stocks) while the figure was just 10% in France.

Table 6: From millennial investors (Calastone, 2020).

Place of Comparison	Financial Security Ownership
Hong Kong	48%
France	10%

Place of Comparison	Financial Security Ownership

- In Portugal, Estonia, and elsewhere young people are suing companies for eco-problems: Flor (2024)
- The En-ROADS climate change solutions simulator allows governments, organizations and individuals explore climate scenarios based on interactive changes in a visualization tool (Czaika & Selin, 2017; Creutzig & Kapmeier, 2020; Climate Interactive, 2023, n.d.).
- “Research shows that showing people research doesn’t work,” John Sterman

Pollution Levels

Taiwanese college students are subjected to high levels of pollution.

University campuses are somewhat healthier than other areas.

There are several decades of research on pollution levels in Taiwan, most with very scary correlations to health.

- Taiwan air pollution, the worst (highest PM2.5 concentration) were found in Changhua (24.5 $\mu\text{g}/\text{m}^3$), Tainan (20.9 $\mu\text{g}/\text{m}^3$), and Pingtong (20.7 $\mu\text{g}/\text{m}^3$) (Chang Hsiung-feng, Wu Che-hao & Wu Kuan-hsien, 2024).

religion plays a role in pollution: <https://www.taipeitimes.com/News/taiwan/archives/2014/08/10/2003597086>

Developing Personas

User research makes extensive use of user *personas* to represent a group of people with similar attributes. Designers use personas to *articulate assumptions*, which, if used well, is useful for *user-centered design*, to create better products. Personas help to reflect on what kind of *biases* might exist in the design. Within the larger cohort of college students several different personas could be defined, for example grouping people by interests, knowledge, habits, levels of anxiety, and other attributes.

There have been concerns about food safety in Taiwan

Humans have a long list of cognitive biases, which a good design should take into account.

There is extensive research on the attitudes of U.S. college students towards climate change. (American Press Institute, 2022) reports only 37% percent of U.S. Generation-Z and Millennials follow news related to environmental issues. (Schwartz et al., 2022) reports some adult US students in a small study (18-35, n = 284) express feelings of insignificance of their actions to achieve any meaningful impact. (Thomaes et al., 2023) reports U.S. adolescents don't find sustainability relevant to their daily life. (Ross et al., 2016) says most people in the U.S. don't act on climate change. “Action on climate change has been compromised by uncertainty, aspects of human psychology”.

Students ride bicycles and scooters. Many circular economy service such as YouBike and transport sharing platforms like Uber are available.

Many students live in dorms and shared housing, meaning their impact per square meter is low.

- Students in the Generation-Z age bracket (abbreviated as Gen-Z or Zoomers) are born between 1997 and 2012 (Branka Vuleta, 2023). Over 98% of Gen-Z owns a smartphone while only 80% of the general world population does (Global Web Index, 2017; BankMyCell, 2022).
- High levels of technology adoption worldwide
- (Credit Suisse, 2022) suggests young consumers are more eco-friendly and drive the speed of change. Yet the Economist has ran a few anonymous articles calling gen-z green ideals into question (The Economist, 2023; Anon, 2023o).
- Deyan Georgiev (2023a)
- Alex Reice (2021)

The above studies give foundation for creating a persona of a U.S. College Student who doesn't follow environmental news and thinks climate action doesn't make a difference. This doesn't necessarily mean this group of people with similar ideas would deny climate change is happening. Rather "Climate Denier" could be another persona, grouping people into a cohort who thinks climate change is not real. Further research would be needed to define relevant personas which have meaningful predictive and generalizing power.

Table 7: College Student Personas

Description	Name	Beliefs
Climate Change Denier	Jake	Climate change doesn't exist.
	Alice	
	Sam	

- Crabb (2023)

Rooney-Varga et al. (2019) shows the effectiveness of *The Climate Action Simulation* in educating users about **success scenarios**.

Social Trust

- When disaster hits we need high levels of social trust.

Climate Anxiety

A large worldwide study (n=10000, age 16-25) by (Hickman et al., 2021) provides evidence the youth is anxious about climate in Australia, Brazil, Finland, France, India, Nigeria, Philippines, Portugal, the UK, and the USA. Similarly, (Thompson, 2021) finds young people around the world have climate anxiety. (Whitmarsh et al., 2022) shows worry about the climate in the UK is generally widespread (over 40% of the respondents, n=1332), while climate anxiety is highest among young

people and is a possible motivator for climate action. Additionally, (Ogunbode et al., 2022) finds climate anxiety in 32 countries and also supports the idea that climate anxiety leads to climate activism. (Thibodeau, 2022): “In 2021, the BBC polled 1,000 people in Scotland to understand the barriers to taking climate action. What they found was even though many people were aware of actions needed to take to address climate change, and had intentions to their behaviors didn’t change. This is a phenomenon called the intention-action gap.”

- (Osaka, 2023) argues *doomerism* is an excuse for climate in-action. Hope is necessary for people to make changes in their habits (Marlon et al., 2019).
- Designing for Health and Sustainability: Health and sustainability are intrinsically connected. (Kjaergard, Land & Bransholm Pedersen, 2014) shows how “understanding health and sustainability as a duality, health both creates conditions and is conditioned by sustainability, understood as economic, social and environmental sustainability, while on the other hand sustainability creates and is conditioned by human health”
- Design for Human Rights (UNFCCC, 2023b)] text refers to “human right to a clean, healthy and sustainable environment”.
- Refi podcast: “people need agency”.
- Martiskainen et al. (2020) (need access, ncku doesn’t subscribe)
- Seabrook (2020) (need access)
- Older research on young adults (Millenials at the time) highlights how Millenials “use Google as a reference point for ease of use and simplicity” (Kate Moran, 2016).

Community

Humans working together are able to achieve more than single individuals. “Any community on the internet should be able to come together, with capital, and work towards any shared vision. That starts with empowering creators and artists to create and own the culture they’re creating. In the long term this moves to internet communities taking on societal endeavors.”

- Building a culture of sustainability? (Lakshmi Rebecca, 2018; Armstrong & Staff, 2021).

The focus on *group consciousness* suggests community-based sustainability action may be effective.

Zero Waste Lifestyle is the opposite of overconsumption. Zero waste suggests people buy in bulk to save. Buying in bulk for more savings and to reduce packaging. Through group purchases and community investing while also reducing consumption. - Zero waste municipality in Treviso

Minimalism is a movement of people living a simple life. This is always going to be a small percentage of people. (Costa, 2018): Finnish socialists: minimalism. Tokyo (Tokyo Simple Eco Life, 2021).

What are the building blocks of a thriving community?

- Taiwan is a growing market for luxury brands (Karatzas, Kapoulas & Priporas, 2019).

Empowerment

- I would like to have an AI agent to set my requirements and preferences and give a “fuck you” middle finger to companies that don’t meet them. I could also give a thumbs up to companies that meet my expectations. Perhaps the user interface could like Tinder where I can swipe left and right.

Trends and Memes

- 2024 “underconsumption” and “deinfluencing” are trends on TikTok.
 - <https://www.tiktok.com/search?q=underconsumption>
 - <https://www.tiktok.com/search?q=deinfluence>
 - <https://www.tiktok.com/tag/deinfluencing>
 - <https://www.tiktok.com/tag/underconsumption>
- Coined by Richard Dawkins in 1976 in the context of biology.
- Internet memes and meme stocks
- Memes from daily life, business to war, are relevant to penetrating through the noise of the web.
- Memes and sustainability?
- Meme research has become an academic discipline
- Memes have become a popular communication tool..
- Zidani (2021)
- Zidani & Miltner (2022)
- Irina Lyan, Limor Shifman & Sulafa Zidani (2015)
- Zannettou et al. (2018)
- Peters-Lazaro, Shresthova & Jenkins (2020)

Design Implications

College Students Need Tools for Action

Environment shapes action.. create an environment where college students can influence companies.

Category	Implication
Community	Taiwanese students are influenced by the actions of their peers; the app should show what other people are doing. People exist in relation to other people. Psychology of ‘fundraising clubs’ vs individual investing

Category	Implication
Climate Anxiety	<p>Anon (n.d.bx) Ukraine DAO to support Ukraine through web3.</p> <p>These social movements are small and require too much effort to be feasible for the app? Most college students are not zero waste or minimalist.</p> <p>Group Purchases.</p> <p>Find Your Composting Community.</p> <p>Provides a community for pooling money with like-minded investors.</p>
Social Trust	<p>How to support the youth? Design to reduce climate anxiety? Is getting people to go to nature more a good way to increase ecological awareness? Empowered by Design.</p> <p>Youth empowerment: The design should empower young people.</p> <p>Consumer branded carbon credits like angry teenagers?</p> <p>Invest time not money, student don't have money?</p> <p>Show Success Scenarios!</p>

Category	Implication
	<p>aespa (2020): Karina from Korea. It makes sense your sustainability assistant would talk to you. Studies show gen N is speaking to computers all the time. Interacting with the user is on the rise. For example, Chime makes tipping suggestions on the place of purchase.</p> <p>The demographics that stand to win the most from the green transformation of business are the youngest generations, with more years of life ahead of them, and more exposure to future environmental and social risks. It would be advisable for Generation Z and their parents (Millennials) to invest their resources in greener assets, however, it's still difficult to pick and choose between 'good' and 'bad' financial vehicles to invest in.</p> <p>This creates an opportunity for a new generation of sustainable investment apps, focusing on the usability and accessibility of ESG for a mainstream audience. Generation Z and Millennials expect a consumer-grade user experience. What would that experience look like? I've chosen these demographics with the assumption that if given the right tools, the emotional demand for sustainability could be transformed into action. The exploration of systems of feedback to enable consumers to apply more direct positive and negative pressure to the businesses and consumers signal consequences for undesirable ecological performance is a major motivation of this study.</p>

Sustainability

Defining “Sustainability” - “**Nachhaltigkeit**” - *sustainability* in German - was likely the first use of the concept of preserving natural resources, conceived by a tax accountant Hannß Carl von Carlowitz in 1713 in his seminal book on forestry - *Sylvicultura oeconomica* -, referring to the goal of achieving prudent forest management practices in his native Saxony in Southeastern Germany, which at the time was under severe *deforestation* pressure from mining, ship-building and agricultural production (Hannß Carl von Carlowitz, 1713; Gottschlich & Friedrich, 2014). This particular field of sustainability study is now known as *sustainable yield of natural capital*. The *principal* of the natural resource being managed, such as in fishing and forestry, shouldn’t be over-harvested in order to maintain *ecosystem services* - a contemporary term from the theory of *natural capital*, referring to benefits humans receive from the stock of world’s natural resources (Peter Kareiva et al., 2011). Perhaps more poetically, the American wildlife ecologist Aldo Leopold proposed the idea of *land ethics* in 1972 as “[a] thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise” in his landmark work *A Sand County Almanac* (Leopold, 1972). In a similar vein, the 1987 United Nations’ Brundtland Report titled “*Our Common Future*” defined *sustainable development* as “*Development that meets the needs of the present without compromising the ability of future generations to meet their own needs*” (Anon, 1987). Given these varied ideas for over 300 years, I believe some percentage of people have been concerned with our planet’s natural environment and its preservation already for centuries. Yet, it is only in the last 100 and so years that human activities have begun to affect Earth’s systems on a previously unseen scale - termed *Anthropocene* -, necessitating a deeper understanding of human-nature interactions, such as in the case of climate change, which is rapidly changing the face of our living environments.

Measuring and Visualizing Earth’s Climate

Studies of Earth’s climate go back for over 200 years, starting with Alexander von Humboldt, the founder of climatology, who revolutionized cartography by inventing the first *isothermal maps* in 1816; these maps showed areas with similar temperature, variations in altitude and seasons in different colors (Honton, 2022) now available as 3D computer models(Anon, 2023p). Already in 1896, the Nobel Prize winner Svante Arrhenius first calculated how an increase in CO₂ levels could have a warming effect on our global climate (Anderson, Hawkins & Jones, 2016; Wulff, 2020). In 1938, Guy Stewart Callendar was the first scientist to demonstrate the warming of Earth’s land surface as well as linking the production of fossil fuels to increased CO₂e and changing climate (Hawkins & Jones, 2013). Early scientists pioneered climate modeling by calculating the first climate interactions which precede today’s complex computer-based *Earth System Models (ESMs)* that integrate the various Earth systems and cycles run on supercomputers (Anderson, Hawkins & Jones, 2016).



Figure 3: Humboldt's Naturgemälde, early data visualization of ecology, rain, temperature, elevation, etc

While the scientific case for human-induced climate change was building, it took 120 years after Arrhenius' calculations, until the Paris Climate Agreement in 2016, that countries came to an agreement on non-binding targets on keeping CO₂ levels 1.5 °C below pre-industrial levels (defined as 1850–1900)(United Nations, 2016). Even though awareness of Earth's warming climate was growing ever stronger, the CO₂ emissions kept rising too. The hockey-stick growth of CO₂ concentration since the industrial revolution is clear in the data from 1958 onward, following a steady annual increase, called the *Keeling Curve* (Keeling & Keeling, 2017). Written records of global temperature measurements are available starting from the 1880s, when temperatures began to be documented in ship logs (Brohan et al., 2012). Finally, although perhaps less accurately, temperature estimations from tree-trunks allow some comparisons with the climate as far back as 2000 years ago (Rubino et al., 2019).

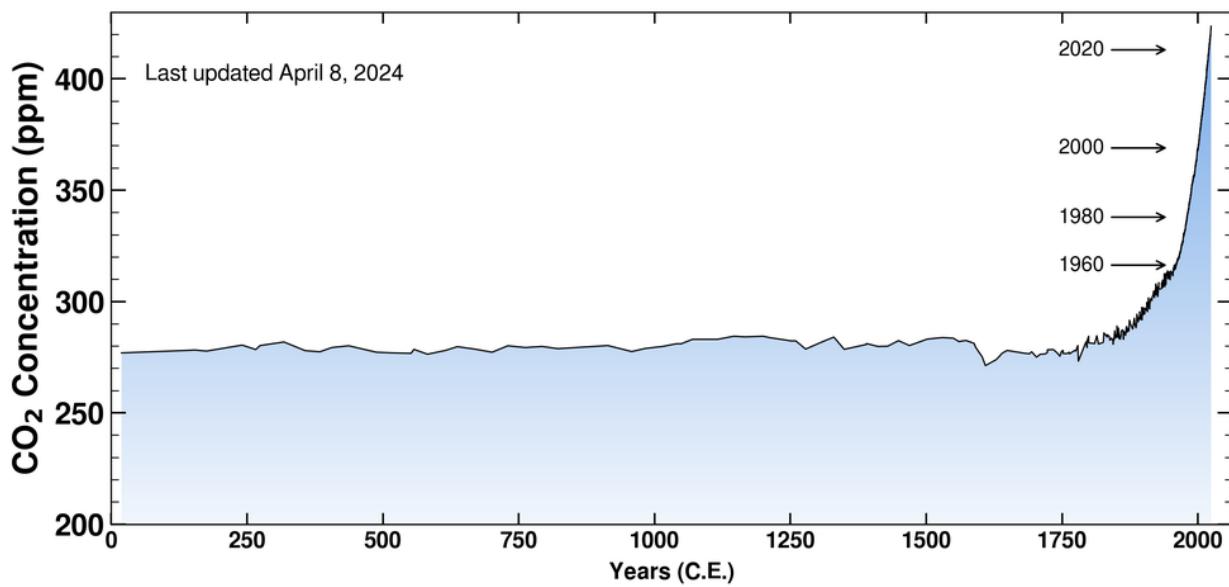


Figure 4: CO₂ concentration in the atmosphere as of Ap. Image Credit: Scripps Institution of Oceanography at UC San Diego.

The latest data from 2023 shows our current world population of 8 Billion people emitted 37.2 gigatonnes (i.e. billion metric tons) of CO₂e per year, the highest emissions recorded in history (Statista, 2023a). In order to limit global warming to 1.5 °C as agreed by the world nations in Paris, removal of 5-20 gigatons of CO₂e per year would be needed according to reduction pathways calculated by the Intergovernmental Panel on Climate Change (IPCC) (Wade et al., 2023). Yet, most countries are missing the mark (Climate Analytics & NewClimate Institute, 2023; United Nations Environment Programme, 2023). The European Union's Copernicus Climate Change Service (C3S) reports 1.5 °C global warming has already been breached in 2024 temperatures (Anon, 2024j; Anon, 2024d). Given the current pace of climate change action, the G7 countries (Canada, France, Germany, Italy, Japan, United Kingdom, United States) are heading for 2.7 °C of warming by 2050 (CDP, 2022).

Earth's physical systems are very sensitive to small changes in temperature, which was not understood until the 1970s(McKibben, 2006). A comprehensive review of evidence from paleoclimate records until current time, including ocean, atmosphere, and land surface of points towards substantial climate change if high levels of greenhouse gas emissions continue, termed by the authors as *climate sensitivity* (Sherwood et al., 2020). Global warming may lead to the slowing down and complete stop of the Atlantic meridional overturning circulation (AMOC) which helps maintain climate stability (Ditlevsen & Ditlevsen, 2023).

The most complex computer models which attempt to capture ever more interactions happening in the physical realm are called Digital Twins. The EU is developing a digital twin of Earth to help sustainability prediction and planning, integrating Earth's various systems such as climate, hydrology, ecology, etc, into a single model Anon (2023f). We can use all the data being recorded to provide a digital twin of the planet, nature, ecosystems and human actions to help us change our behavior and optimize for planetary wellbeing.

Biosphere and Ecological Indicators

Earth's biosphere is made up of 846 terrestrial ecoregions, which are distributed across 14 major biomes and 8 biogeographical realms (Dinerstein et al., 2017).

Ecological Indicators (I like the name Ecomarkers) for Earth are like *Biomarkers* in human health. Sustainability can be measured using a variety of *ecological indicators*.

Many technological advances help scientist better understand nature. Cutting edge research uses AI-based voice recognition for listening to nature, assessing biodiversity based on species' sounds in the forest. Millions of detections of different species with machine learning passive acoustic AI models, can also assess species' response to climate change (AI for Good, 2023; Guerrero et al., 2023). *Environmental DNA* (eDNA) helps scientists measure species without direct observation through detection of DNA on genetic materials such as skin cells (Peter Andrey Smitharchive page, 2024). Cellular DNA can be isolated from various sediment types (Ogram, Sayler & Barkay, 1987). AI is being used to map icebergs and measure the change in size (European Space Agency, 2023).

- Jackson (1996) *preventive environmental management*

Pricing, Tracing and Trading CO₂e Emissions

While technology improves and measurements become more accurate, CO₂e emissions are not yet completely accounted for. (Crippa et al., 2020) reports latest figures CO₂e from the EU's Emissions Database for Global Atmospheric Research (EDGAR). The EU Copernicus satellite system reveals new greenhouse emissions previously undetected (Daniel Värjö, 2022). *Copernicus Climate Change Service (C3S)* provides “[n]ear-real time updates of key global climate variables” **.

- According to (Debnath et al., 2022) 39% of global CO₂ emissions comes from the building sector. Construction is large emitter because of the use of concrete; super tall buildings are very CO₂ intensive (Zhao & Qin, 2015).

Emissions production is highly unequal. “The world’s top 1% of emitters produce over 1000 times more CO₂ than the bottom 1%” IEA (2023a)

CO₂e emissions by region (per year).

Table 9: Comparing highest per capita CO₂e emissions (mostly from oil producers) vs regional average per capita CO₂ emissions vs total CO₂ emissions(Ivanova et al., 2020; World Resources Institute, 2020; European Commission. Joint Research Centre., 2022; Crippa et al., 2020; Liu et al., 2023d).

Regional Average Per Capita Emissions (2020)	Highest Per Capita Emissions (2021)	Highest Total Emissions (2021)
North America 13.4 CO ₂ e tonnes	Palau	China
Europe 7.5 CO ₂ e tonnes	Qatar	United States
Global Average 4.1 CO ₂ e tonnes	Kuwait	European Union
Africa and the Middle East 1.7 CO ₂ e tonnes	Bahrain	India
	Trinidad and Tobago	Russia

New Caledonia	Japan
United Arab Emirates	Iran
Gibraltar	Germany
Falkland Islands	South Korea
Oman	Indonesia
Saudi Arabia	Saudi Arabia
Brunei Darussalam	Canada
Canada	Brazil
Australia	Turkey
United States	South Africa

Scoping

Scoping CO_{2e} emissions into 4 main categories helps to organize calculating CO_{2e} emissions and corresponding reduction targets by looking at direct and indirect emissions separately. The U.S. National Public Utilities Council (NPUC) decarbonization report provides a useful categorization of *emission scopes* applicable to companies which helps organizing emission reduction schemes (National Public Utilities Council, 2022) based on the Greenhouse Gas Protocol defined in the 1990s (GHG Protocol, n.d.). For example, for consumers in Australian states and territories in 2018, 83% of the GHG emissions are Scope 3, meaning indirect emissions in the value chain (Goodwin et al., 2023). A newer concept is Scope 4 emissions also known as avoided emissions, proposed by the World Resources Institute (WRI) in 2013 (Plan A, n.d.).

Table 10: Definition of Emission Scopes From (National Public Utilities Council, 2022).

Emission Scope	Emission Source
Scope 1	Direct emissions
Scope 2	Indirect electricity emissions
Scope 3	Value chain emissions
Scope 4	Avoided emissions

One's scope 3 emissions are someone else's scope 1 emissions.

- Mapping pollution sources in China Xie et al. (2021)

Countries have agreed up CO_{2e} Reduction Targets known as Country-Level Nationally Determined Contributions (NDCs)

- UNFCCC. Secretariat (2022) The State of Nationally Determined Contributions

While most countries have not reached their Nationally Determined Contributions, the Climate Action Tracker data portal allows to compare countries (Climate Analytics & NewClimate Institute, 2023).

Table 11: Climate Action Tracker's country comparison of the 10 top polluters' climate action.

Country or Region	NDC target
-------------------	------------

China	Highly insufficient
Indonesia	Highly insufficient
Russia	Critically insufficient
EU	Insufficient
USA	Insufficient
United Arab Emirates	Highly insufficient
Japan	Insufficient
South Korea	Highly insufficient
Iran	Critically insufficient
Saudi Arabia	Highly insufficient

- (Fransen et al., 2022) notes that the majority of Nationally Determined Contributions (NDCs) are dependent on financial assistance from the international community.
- CO_{2e} assigning a monetary value to carbon emissions.

Trading CO_{2e} emissions can be divided into 2 categories - *Compliance Carbon Markets* (CCM) and *Voluntary Carbon Markets* (VCM).

The legislative baseline for Compliance Carbon Markets is so low, people want to retire more CO_{2e}, which they can do through *Voluntary Carbon Markets*.

For the individual person, there's no direct access to CO₂ markets. However, brokers do buy large amounts of carbon credits to resell in smaller quantities to retail investors.

“Carbon pricing is not there to punish people,” says Lion Hirth (n.d.). *“It’s there to remind us, when we take travel, heating, consumption decisions that the true cost of fossil fuels comprises not only mining and processing, but also the damage done by the CO₂ they release.”*

Long term cost of insufficient climate action is more than *short-term gains* from delaying efforts to reduce carbon emissions.

- The total size of carbon markets reached 949 billion USD in 2023, including Chinese, European, and North American CO₂ trading (LSEG & Susanna Twidale, 02/12/2024, 02:37 PM).
- *The price of CO_{2e} differs across markets.* (Stern, 2022) argues carbon-neutral economy needs higher CO_{2e} prices and believes (Rennert et al., 2022) CO_{2e} price per ton should be 3,6x higher than it is currently. Contrary, (Ritz, 2022) argues optimal CO₂ prices could be highly asymmetric, low in some countries and high (above the social cost of CO_{2e}) in countries where production is very polluting.
- iGenius (2020)

CO₂ credits has given rise to *Carbon Accounting industry*.

- Watershed is a large carbon accounting company.
- The legislation has created an industry of CO₂ accounting with many companies like Greenly, Sustaxo, etc.
- Quatrini (2021) sustainability assessments are complex and may give flawed results.

- Nonetheless, CO₂ emission reduction has the added positive effect of boosting corporate morale (Cao, Li & Hasan, 2023).

Compliance Carbon Markets

meet legal emission reduction targets

Cap & Trade

The share of CO₂ emissions among people around the world is highly unequal across the world (referred to as ***Carbon Inequality***). (Chancel, 2022) reports “one-tenth of the global population is responsible for nearly half of all emissions, half of the population emits less than 12%”.

- One example is the ICT sector.
- Bajarin (n.d.) Over 300 million PCs sold in 2022
 - Anon (2021h) Estonian company “sustainable lifecycle management of IT equipment”
 - Ärileht (23.09.2022, 12:53) Recycle your phone, FoxWay and Circular economy for PCs.
 - Zhou et al. (2022a) ICT is an example of inequality, while emerging economies bear 82% of the emissions, developed countries gain 58% of value.

Emissions Trading Schemes

From Carbon Offsets to Carbon Credits

- “A carbon credit represents one tonne of carbon dioxide that has been prevented from entering or has been removed from the atmosphere” (Anna Watson, 2023, 2022).

Retiring CO₂ allowances

- Facilitating citizens’ access to CO₂ emissions trading may be an efficient method to organize large-scale CO₂ retiring (Rousse, 2008).

As of 2024 there’s no single global CO₂ trading market but rather several local markets as described in the table below.

Table 12: CO₂ credit trading markets around the world from Anon (n.d.an).

CO ₂ Market	Launch Date	Comments
EU	2005	EU: Araújo et al. (2020)
South Korea	2015	
China	2021	China’s national emissions trading scheme (ETS) started in 2021 priced at 48 yuan per tonne of CO ₂ , averaged at 58 yuan in 2022 (Liu, 2021; Ivy Yin, 2023).
U.S.	2013	No country-wide market; local CO ₂ markets in California, Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont

New Zealand	2008	New Zealand Rontard & Reyes Hernández (2022) (need access, important ncku doesn't subscribe)
Canada	2013	

Most of the world is not part of a CO₂ market.

- (Sipthorpe et al., 2022) compares traditional and blockchain-based solutions to carbon trading.
- (United Nations Environment Programme (UNEP), 2021) report. “The Emissions Gap Report (EGR) 2021: The Heat Is On shows that new national climate pledges combined with other mitigation measures put the world on track for a global temperature rise of 2.7°C by the end of the century. That is well above the goals of the Paris climate agreement and would lead to catastrophic changes in the Earth’s climate. To keep global warming below 1.5°C this century, the aspirational goal of the Paris Agreement, the world needs to halve annual greenhouse gas emissions in the next eight years.
- (United Nations Environment Programme (UNEP), 2021) report “If implemented effectively, net-zero emissions pledges could limit warming to 2.2°C, closer to the well-below 2°C goal of the Paris Agreement. However, many national climate plans delay action until after 2030. The reduction of methane emissions from the fossil fuel, waste and agriculture sectors could help close the emissions gap and reduce warming in the short term, the report finds. Carbon markets could also help slash emissions. But that would only happen if rules are clearly defined and target actual reductions in emissions, while being supported by arrangements to track progress and provide transparency.”
- (United Nations Environment Programme, 2022) 2022 Emissions Gap report.

Table 13: Compliance market CO₂ prices on August 12, 2023; data from (Ember, 2023; Trading Economics, 2023; CarbonCredits, 2023).

Compliance Markets	Price (Tonne of CO ₂)
EU	83 EUR
UK	40 Pounds
US (California)	29 USD
Australia	32 USD
New Zealand	50 USD
South Korea	5.84 USD
China	8.29 USD

- tree bark absorbs methane, (Gauci et al., 2024).

Voluntary Carbon Markets

Verified Carbon Standard (VCS) and the Gold Standard, Climate Action Reserve (CAR), American Carbon Registry (ACR)

Voluntary Carbon Markets are ...

Voluntary Carbon Markets (VCM) lack standardization and transparency (Ela Khodai, 2023).

Carbon Credits are useful for private companies who wish to claim *carbon neutrality*, *climate positivity*, or other related claim, which might be viewed in good light by their clients or allow the companies to adhere to certain legislative requirements.

There are many companies which facilitate buy carbon credits as well as a few organizations focused on carbon credit verification.

- In Estonia, startups Arbonic and Single.Earth are trialing this approach in several forests.
- Carbon Credit Retirement?
- Methodologies: Anon (2022h)
- KlimaDAO (2023) call for an open standard

Table 14: Voluntary market CO₂ prices on August 12, 2023; data from (CarbonCredits, 2023).

Voluntary Markets	Price (Tonne of CO ₂)
Aviation Industry Offset	\$0.93
Nature Based Offset	\$1.80
Tech Based Offset	\$0.77

Consumerism > Earth's Boundaries

Earth's growing population reached 8 Billion people In November 2022 and population projections by predict 8.5B people by 2030 and 9.7B by 2050 (The Economic Times, 2022; United Nations Department of Economic and Social Affairs, Population Division, 2022). While population growth puts higher pressure on Earth's resources, some researchers propose the effect is higher from wasteful lifestyles than the raw number of people (Cardinale et al., 2012) while others such as (Cafaro, Hansson & Götmark, 2022) believe "*Overpopulation is a major cause of biodiversity loss and smaller human populations are necessary to preserve what is left*" .

Making *anything* consumes natural resources, which are limited on planet Earth.

Environmental risks from human activities are known as Anthropogenic Threat Complexes (ATCs) (Bowler et al., 2020).

- Jackson (2017) limits to growth update

Consumer lifestyle - overconsumption - is one of the main drivers of climate change and environmental destruction. "2/3 of global GHG emissions are directly and indirectly linked to household consumption, with a global average of about 6 tonnes CO₂ equivalent per capita" (Renee Cho, 2020; Ivanova et al., 2020). (Hassoun et al., 2023) forecasts increase of global food demand by 62% including impact of climate change. According to (Ellen MacArthur Foundation, Material Economics, 2019)'s models 45% of CO₂ equivalent emissions come from our shopping; produced by companies to make the products we consume.

Overconsumption is also one of the root causes of plastic pollution. (Ford et al., 2022) and (Lavers, Bond & Rolsky, 2022) find strong links between climate change and marine plastic pollution "*along with other stressors that threaten the resilience of species and habitats sensitive to both climate change and plastic pollution*". (Lavers, Bond & Rolsky, 2022) plastic pollution is pervasive around the Earth and is fundamentally linked to climate change.

A large scale study by Anthony Leiserowitz et al. (2022) on Meta’s Facebook (n=108946) reported people in Spain (65%), Sweden (61%), and Taiwan (60%) believe “*climate change is mostly caused by human activities*”. An even larger survey (n=1.2 million) by the United Nations across 50 countries, distributed through mobile game ads, showed the majority of people agreeing climate change is an “emergency” (UNDP, 2021). While people express eco-conscious ideas, it’s non-trivial to practice sustainability in daily life. (Deyan Georgiev, 2023b) reports only 30% of people in the Gen-Z age group believe technology can solve all problems.

Table 15: 1.2 million UN survey responses to the statement “*Climate change is an emergency*” (UNDP, 2021).

Age Group	Agree	Neutral or Disagree
18-35	65%	35%
36-59	66%	34%
Over 69	58%	42%

While the numbers on overconsumption are clear, the debate on overconsumption is so polarized, it’s difficult to have a meaningful discussion of the topic (Iano & Cornescu, 2013).

- Overconsumption and underinvestment.
- Cities are responsible for 80% of the emissions Rosales Carreón & Worrell (2018)
- Moberg et al. (2019) reports daily human activities emission contribution on average in four European countries (France, Germany, Norway and Sweden).

Table 16: Daily human activities emission contribution on average in France, Germany, Norway and Sweden from Moberg et al. (2019).

Emission Share	Category
21%	Housing
30%	Food
34%	Mobility
15%	Other

- Armstrong McKay et al. (2022) discusses tipping points.

In addition to the enormity of over-reaching CO₂ emissions, humanity is facing other massive environmental problems. The Stockholm Resilience Centre reports we have already breached 4 out of our 9 “*planetary boundaries*”: in addition to climate change, biodiversity loss (Extinctions per Million Species per Year aka E/MSY), land-system change (deforestation, land degradation, etc), and biogeochemical flows (cycles of carbon, nitrogen, phosphorus, etc); on a positive side, the challenges of fresh water use, ocean acidification and stratospheric ozone depletion are still within planetary limits (Persson et al., 2022).

- Ceballos, Ehrlich & Dirzo (2017) mass extinctions
- IUCN Red List: 45,300 species (28% of all assessed) under threat of extinction IUCN (2024)

Atmospheric aerosol loading and the biodiversity intactness index (BII) were quantified recently (ADD CITATION)

- (Keeble, 1988) reported in April 1987 that ‘*residents in high-income countries lead lifestyles incompatible with planetary boundaries*’. While my home country Estonia at the time was considered low-income, a small nation in poverty behind the *Iron Curtain* occupation of the Soviet Union, we now in 2024, have also reached high-income status.
- De Balie (2018)
- Houdini (2018)
- Haeggman, Moberg & Sandin (2018)

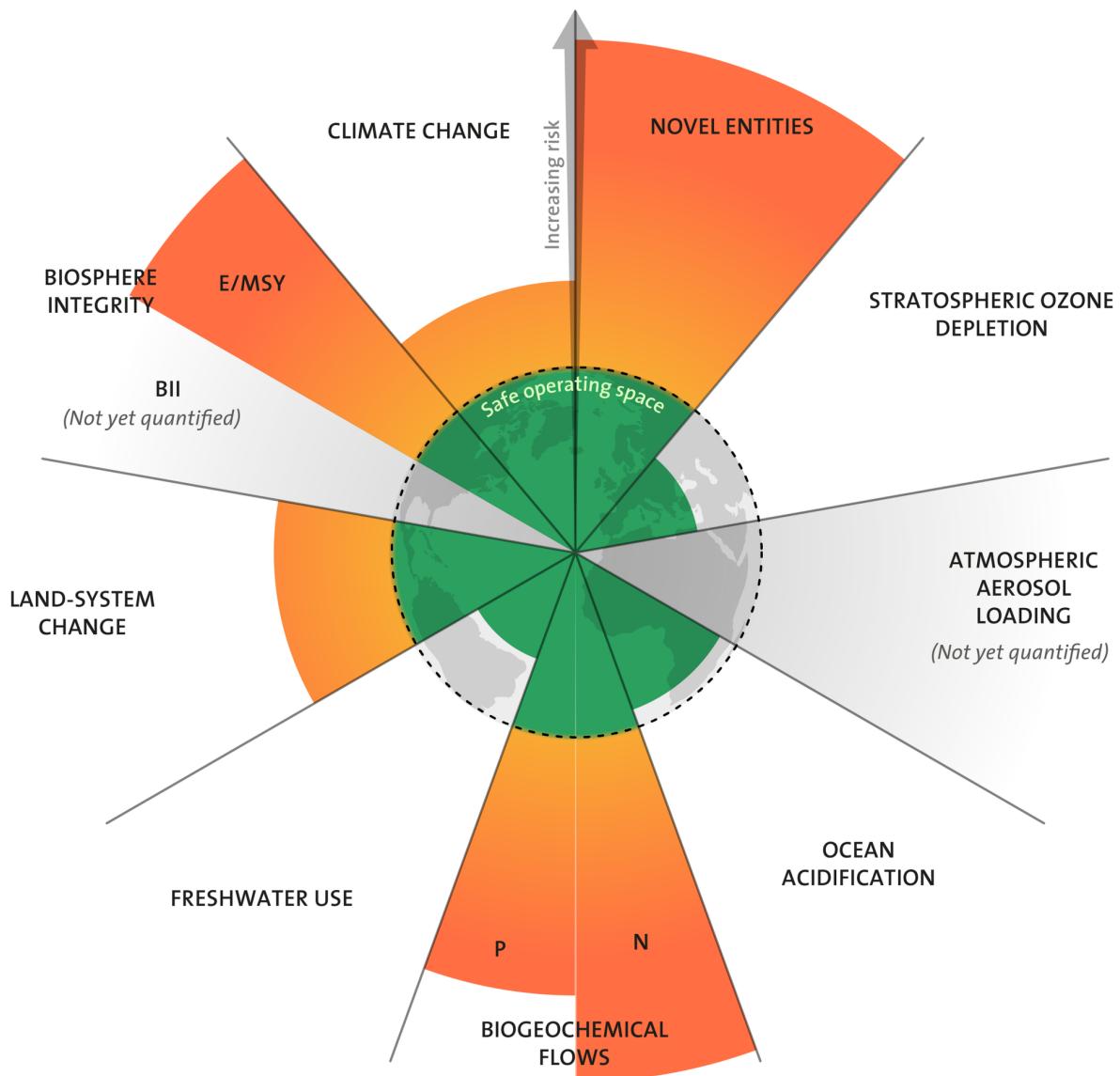


Figure 5: Planetary Boundaries. J. Lokrantz/Azote based on Steffen et al. 2015

In 1948, the International Union for Conservation of Nature (IUCN) was founded, which in

LULUCF “Land Use, Land-Use Change, and Forestry” can both be a source of greenhouse gas emissions - or a carbon sink (removing CO₂ from the atmosphere).

As long as humanity is a mono-planetary species, we have to come to terms with the limitations of our home, Earth.

Earth System Law, Planetary Health, and Social Cost of CO₂

Cross-disciplinary scientists have been working on integrating Earth systems and human society into cohesive frameworks. *Planetary Health, Earth System Law, and Social Cost of Carbon* are 3 approaches to address the complex interdependence of humans with our physical environment.

Evolving Measurements from Planetary Boundaries to Planetary Health

- Planetary health (Planetary Health Alliance, 2024a, 2024b)
- Wardani et al. (2023) *“long-term human well-being is dependent on the well-being of the planet, including both biotic and abiotic systems. It recognizes interlinkages across environmental sustainability, public health, and socioeconomic development.”*
- (Du Toit & Kotzé, 2022) describes *Earth System Law* as a framework for addressing interconnected environmental challenges.

Earth system science

Social Cost of Carbon Measures Compound CO₂ Impact.

Sustainability is filled with complexities. CO₂ emissions are complicated by biodiversity loss, child labor, slavery, poverty, chemical pollution, etc. - many issues become intertwined (TEDx Talks, 2020). One attempt to measure these complexities, is the *Social Cost of Carbon* (SCC) which is defined as *“additional damage caused by an extra unit of emissions”* (Kornek et al., 2021; Zhen, Tian & Ye, 2018). For example the cost of damages caused by “one extra ton of carbon dioxide emissions” (Stanford University, 2021). SCC variations exists between countries (Tol, 2019) and regions (Wang, Ma & Wang, 2022).

- As shown in the Phillipines by (Cheng & Han, 2022), with increasing extreme weather events, “businesses are more likely to emerge in areas where infrastructure is resilient to climate hazards”. (Jerrett, Jina & Marlier, 2022) says, In California, “Wildfires are the second most important source of emissions in 2020” and “Wildfires in 2020 negate reductions in greenhouse gas emissions from other sectors.”
- (Lin et al., 2022a) says, apart from CO₂, reduction of other atmospheric pollutants, such as non-CO₂ greenhouse gases (GHGs) and short-lived climate pollutants (SLCPs) is required for climate stability.
- (Wang & Teng, 2022): Quantifying climate damage proposes scenarios of climate damage.

Ecosystem Services

Ecosystem services measure the benefits humans receive from the biosphere. Put most simply, *ecosystem services* enable human life on Earth. While it can be assumed much of the flora and fauna are crucial for Earth's systems, science is still in the process of understanding and quantifying its contributions. The history of the valuation of nature's services goes back to the 18th century when David Ricardo and Jean Baptiste Say discussed nature's *work*, however both considered it should be free (Gómez-Baggethun et al., 2010). In 1997 (Anon, 1997) proposed the idea of *ecosystem services* and (Costanza et al., 1997) attempted to assess the amount of ecosystem services provided. (Le Provost et al., 2022)'s study shows *biodiversity* as one key factor to maintain delivery of ecosystem services. (Noriega et al., 2018) attempts to quantify the ecosystem services (ES) provided by insects.

Why Protect Biodiversity?

May (2011) argues biodiversity loss is a concern for 3 points of views:

Table 17: From May (2011).

View	
Narrowly Utilitarian	Biodiversity is a resource of genetic novelties for the biotech industry.
Broadly Utilitarian	Humans depend upon biodiverse ecosystems.
Ethical	Humans have a responsibility to future generations to pass down a rich natural world.

- (Leverhulme Centre for Nature Recovery, 2023) asks should we put a price on nature?
- Is it time to leave utilitarian environmentalism behind? Muradian & Gómez-Baggethun (2021)

Table 18: From (Leverhulme Centre for Nature Recovery, 2023).

9 Steps
Identify ecosystem functions
Quantify ecosystem functions
Identify ecosystem services
Quantify ecosystem services
Quantify financial value of ecosystem services
Assign property rights
Create ecosystem service markets
Commodify nature

There are 2 main approaches to protecting nature:

Economics of Nature	Measure and assign value to nature
Commodification	

Economics of the Sacred	Nature is sacred - such as are religious holy places - and can't be touched (Eisenstein, 2011, 2018)
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- Han & Chen (2022) identifies nature-based solutions “land re-naturalization (such as afforestation and wetland restoration)”

Table 20: From Han & Chen (2022)

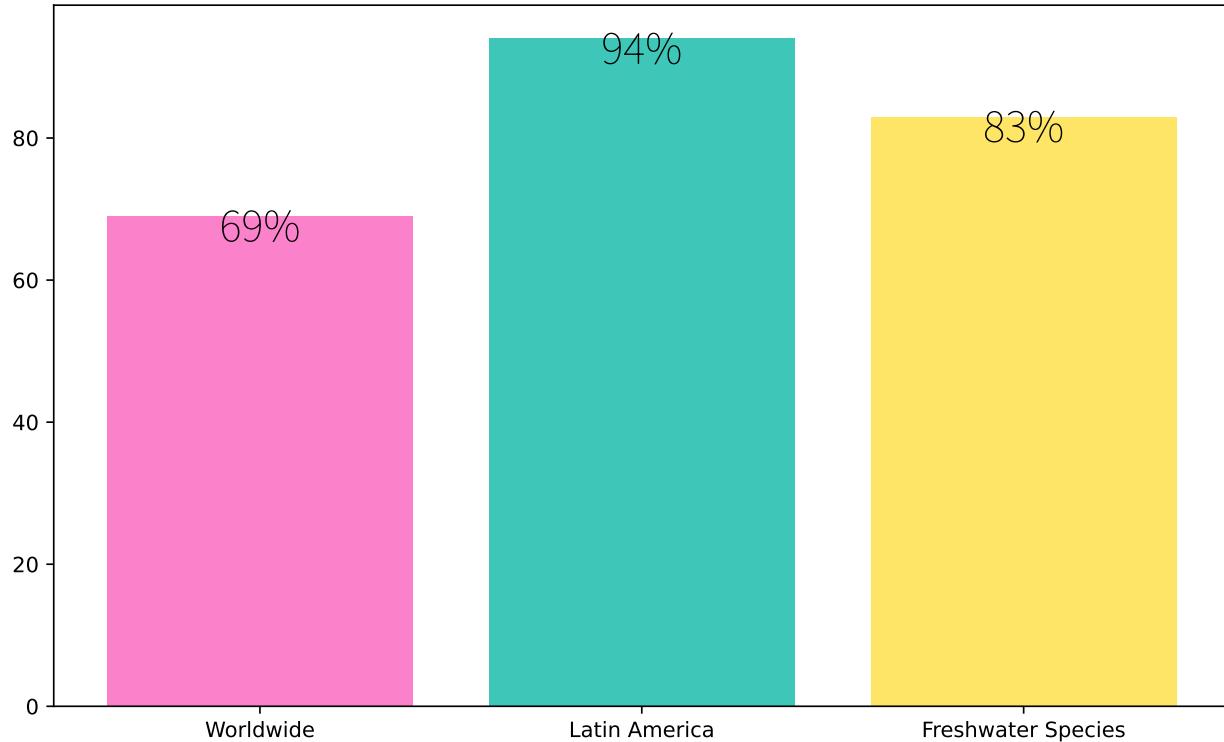
Non-Exhaustive list of
Afforestation
Wetland restoration

- Meanwhile the destruction pressure on ecosystems is rapidly increasing (ADD CITATION A B C).
- Espinosa & Bazairi (2023) marine ecosystem services (**need access, ncku doesn't sub**)
- Chen et al. (2023) Ecosystem vulnerability (**need access**)
- Zhang et al. (2023b) Integrating ecosystem services conservation into urban planning (**need access**)
- Li et al. (2023) tourism is a large industrial sector which relies on ecosystem services. In Taiwan, (Lee, Jan & Liu, 2021) developed a framework of indicators to assess sustainable tourism.

Measuring Environmental Degradation

Biodiversity

(Almond, R.E.A. et al., 2022) reported, the number of species killed, mass destruction of nature. “69% decline in the relative abundance of monitored wildlife populations around the world between 1970 and 2018. Latin America shows the greatest regional decline in average population abundance (94%), while freshwater species populations have seen the greatest overall global decline (83%).”



Biodiversity loss is linked to overconsumption, weak legislation and lack of oversight. (Crenna, Sinkko & Sala, 2019) recounts European Union consumers' negative impact on biodiversity in countries where it imports food. WWF (2022) case study highlights how 4 biodiverse regions Cerrado in Brazil, Chaco in Argentina, Sumatra in Indonesia, and the Cuvette Centrale in Democratic Republic of Congo are experiencing rapid destruction due to consumer demand in the European Union. While the European Union (EU) has recently become a leader in sustainability legislation, biodiversity protection measures among private companies is very low Marco-Fondevila & Álvarez-Etxeberria (2023).

Meanwhile, there is some progress in biodiversity conservation. UEBT (2022) reports "Biodiversity awareness is now at 72% or higher in all countries sampled, compared to only 29% or higher across countries sampled in 2009."

Convention on Biodiversity

Similarly to climate protection, the UN has taken a leadership role in biodiversity protection. Unit (2023): The history of the United Nations Convention on Biodiversity goes back to 1988, when the working group was founded. UNEP (Tue, 12/20/2022 - 07:44): The Convention on Biodiversity 2022 (COP15) adopted the first global biodiversity framework to accompany climate goals.

Protecting biodiversity

Table 21: Biodiversity loss data from (Bradshaw et al., 2021).

What Happened?	How Much?
Vertebrate species population average decline	68% over the last 50 years
Land surface altered by humans	70% of Earth
Vertebrate species extinct	700 in 500 years

Plant species extinct	600 in 500 years
Species under threat of extinction	1 million

Marine Heatwaves

- Gelles & Andreoni (2023) describe how marine heatwaves threaten global biodiversity.

Deforestation

Around 27% of Earth's land area is still covered by forests yet deforestation is widespread all around the world; highest rates of deforestation happened in the tropical rainforests of South America and Africa, mainly caused by agricultural cropland expansion (50% of all deforestation) and grazing land for farm animals to produce meat (38,5%), totaling close to 90% of global deforestation (Anon, 2022e). Forests are a crucial part of Earth's carbon cycle and the main natural CO₂ capture system; due to deforestation, Europe rapidly losing its forest carbon sink (Frédéric Simon, 2022).

- Bousfield et al. (2022) reports there's evidence paying landowners for the ecosystem services their forests provide may reduce deforestation.
- Afforestation is different from reforestation, which takes into account biodiversity.
- Klosterman et al. (2022) using remote-sensing and machine-learning to assess reforestation potential; doesn't take into account political realities.
- Global Forest Cover Change, Earth Engine Hansen et al. (2013)
- 1 billion tree project (Greenfield & @pgreenfielduk, 2021; Anon, 2020; Bastin et al., 2019)
- Burning of biomass undermines carbon capture.

Pollution

Air Pollution

Air pollution is widespread around the planet, with 99% of Earth's human population being affected by bad air quality that does not meet WHO air quality guidelines, leading to health problems linked to 6.7 million premature deaths every year (World Health Organization, 2022). Groundbreaking research by (Lim et al., 2022) analyzed over 400000 individuals in England, South Korea and Taiwan establishes exposure to 2.5 m PM (PM2.5) air pollution as a cause for lung cancer. (Bouscasse et al., 2022) finds strong health and economic benefits across the board from air pollution reduction in France. In (Hannah Devlin, 2022), professor Tony Mok, of the Chinese University of Hong Kong: *"We have known about the link between pollution and lung cancer for a long time, and we now have a possible explanation for it. As consumption of fossil fuels goes hand in hand with pollution and carbon emissions, we have a strong mandate for tackling these issues – for both environmental and health reasons".*

Health and sustainability are inextricably linked. "Human health is central to all sustainability efforts.", "All of these (food, housing, power, and health care), and the stress that the lack of them generate, play a huge role in our health" (Sarah Ludwig Rausch & Neha Pathak, 2021).

The main way to combat air pollution is through policy interventions. (MARIA LUÍS FERNANDES, 2023) the EU has legislation in progress to curb industrial emissions. If legislation is in

place, causing bad air quality can become bad for business. Gu et al. (2023) links air pollution to credit interest rates for business loans in China; companies with low environmental awareness and a history of environmental penalties pay 12 percent higher interest rates.

Clean air is a requirement.

Water Pollution

- Bioswales help catch storm debris and reduce water pollution.
- Clean water and water pollution
- Koch (2022) (**Need access! NYC times**)
- Paris cleans Seine river for Paris Olympics

Soil Pollution

- “Wild and ruderal plants as bioindicators of global urban pollution by air, water and soil in Riyadh and Abha, Saudi Arabia” (Picó et al., 2023) uses Wild and ruderal plants to detect pollution by air, water and soil. Bioindicators of anthropogenic pollution, Pharmaceuticals, pesticides, and other industrial chemicals. Both Abha and Riyadh showed notable levels of pollutants while Riyadh with more industry showed higher levels.

Weather

Extreme Weather

- (Anon, 2023i) The US Global Change Research Program comprehensive report to the US Congress links disaster-risk directly to global warming; for examples increased wildfires damage property, endanger life and reduces air quality, which in effect increases health challenges.

Environmental activists have been calling attention to global warming for decades, yet the world has been slow to act (McKibben, 1989).

- Flood risk mapping might lower property prices in at risk areas (Sherren, 2024).
- In Taiwan disaster risk and hazard mapping, early warning systems, and comprehensive response save lives (Tsai et al., 2021).

Global warming increases the risk of disasters and extreme weather events. As extreme temperatures are increasingly commonplace, there's increased risk of wildfires (Volkova, Roxburgh & Weston, 2021). Summers of 2022 and 2023 were the hottest on record so far, with extreme heat waves recorded in places around the world (Venturelli et al., 2023; Serrano-Notivoli et al., 2023; Douglas, 2023; National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce, 2023; NOAA National Centers for Environmental Information, 2023; Falconer, 2023). As temperatures rise, certain cities may become uninhabitable for humans (CBC Radio, 2021). The summer of 2023 saw extensive wildfires in Spain, Canada, and elsewhere; rapidly moving fires destroyed the whole city of Lāhainā in Hawaii [ADD CITATION]. The part of Earth where the *human climate niche* is becoming smaller (McKibben, 2023). Some parts of South America have seen summer heat in the winter, with heatwaves with temperatures as high as 38 degrees (Livingston, 2023).

- Observed changes in heatwaves (Perkins-Kirkpatrick & Green, 2023).

- Word Economic Forums Global Risks Report 2024 paints a bleak picture of the future with expectations of increased turbulence across the board based on a survey of over 1400 topic experts World Economic Forum (n.d.)

Climate-related disasters can spur action as extreme weather becomes visible to everyone. After large floods in South Korea in July 2023 with many victims, president Joon promised to begin taking global warming seriously and steer the country towards climate action Web (2023); AFP (2023); Al Jazeera (2023). South Korea has a partnership with the European Union European Commission (2023a).

The fossil energy production that's a large part of global CO₂ emissions has caused several high-profile pollution events. Large ones that got international news coverage include Exxon Valdez and Deepwater Horizon.

- Chernobyl and Fukushima
- the Great Pacific Garbage Patch
- Lenton et al. (2023) quantifying human cost of global warming.
- EJAtlas tracks environmental justice cases around the world Scheidel et al. (2020).
- Disputes in Eerola (2022).

Sustainable Action

- The concept of how a public resource is over-used until breaking down as each user only bears a fraction of the cost - known as *tragedy of the commons* - was described by the ecologist Garrett Hardin in 1968 (Hardin, 1968; Meisinger, 2022; Lopez, Pastén & Gutiérrez Cubillos, 2022; Murase & Baek, 2018).

Regenerative Action

There is no single solution to the environmental crisis. Given the enormity of environmental degradation, many different approaches are needed. This chapter documents some of the ongoing work which a sustainability companion could assist college students get involved with.

Restoration Ecology, Agroforestry & Permaculture

Some argue sustainability is not enough and we should work on *regeneration* of natural habitats.

The UN announced 2021-2030 the Decade on Ecosystem Restoration (Fischer et al., 2021).

- Agroecology Baltic Sea Action Group (2023)

Agroforestry plays an active role in achieving Sustainable Development Goals (SDGs) (Ruba & Talucder, 2023);

- Food forests for regenerative food systems.
- Svalbard Seed Vault
- Irwin et al. (2023)
- Yadav et al. (2023)
- Low, Dalhaus & Meuwissen (2023)

- Ollinaho & Kröger (2023) “bioeconomy is not inherently sustainable and may pose considerable risks to biodiversity.”
- De Queiroz-Stein & Siegel (2023)
- Gamage et al. (2023) “Organic food and drink sales in 2019 totaled more than 106 billion euros worldwide.”
- “*Would you rather buy a DogeCoin or a regenerative food forest token?*” Curve Labs founder Pat Rawson quotes Shiller (2019) in ReFi podcast about Kolektivo (ReFi DAO, 2022).

Technology

“Climatech”, Renewable Energy and Transforming Energy Production

Fossil fuels are what powers humanity as well as the largest source of CO₂ emissions. IEA (2022) reports “Global CO₂ emissions from energy combustion and industrial processes rebounded in 2021 to reach their highest ever annual level. A 6% increase from 2020 pushed emissions to 36.3 gigatonnes”. As on June 2023, fossil fuel based energy makes up 82% of energy and is still growing Institute (2023). The 425 largest fossil fuel projects represent a total of over 1 gigatons in CO₂ emissions, 40% of which were new projects Kühne et al. (2022). Tilsted et al. (2023) expects the fossil fuel industry to continue grow even faster. In July 2023, the U.K. granted hundreds of new oil and gas of project licenses in the North Sea (Anon, 2023ab).

Large technology conglomerates and newly founded startups focused on climate solutions (often referred to as *climatech* by the media) have proposed a range of approaches to CO₂ reduction in the atmosphere. These technologies include several types of *carbon capture*, directly from the air (direct air capture or DAC), from the source of pollution, such as using high-performance filters on factory chimneys, as well as nature-based solutions such as large scale tree planting using drones.

Each technology has their own pros and cons. (Vitillo et al., 2022) illustrates how direct air capture of CO₂ is difficult because of low concentration and CO₂ capture at the source of the emissions is more feasible.

- (Gaure & Golombek, 2022) simulate a CO₂ free electricity generation system in the European Union where “98% of total electricity production is generated by wind power and solar; the remainder is covered by a backup technology.”. The authors stipulate it’s possible to power the EU without producing CO₂ emissions.
- **Important:** “**creating sustainability trust in companies in realtime**”
- Howard et al. (2017) argues Oceans play crucial role in carbon capture.

Political Action

- **10 countries use almost 100% renewable energy**

There's ample evidence from several countries suggesting moving to renewal energy brings environmental benefits:

- Amin et al. (2022) suggests “removing fossil fuel subsidies and intra-sectoral electricity price distortions coupled with carbon taxes provides the highest benefits” for both the economy and the environment in Bangladesh.

- Luo et al. (2022) suggests using reinforcement learning to reduce energy use in cooling systems.
- The true cost of products is hidden. The work is hidden.
- Montreal protocol eradicates CFCs and the ozone hole became whole again.

Mitigating Climate Change

The monumental task of removing several gigatons of CO₂ from the atmosphere requires massive policy shifts and collaboration across countries and industries (Mackler, Fishman & Broberg, 2021).

Warming global climate has concrete effects on daily life. Warmer climate helps viruses and fungi spread (Press, 2023). (Williams & Joshi, 2013) higher CO₂ concentrations in the air can cause more turbulence for flights.

Adapting to Climate Change

Many companies are developing technologies for mitigation.

In Brazil, deforestation fell 60% in 1 year, based on remote satellite reconnaissance, after the election of a more pro-environment leadership (Watts, 2023).

- Eesti Vabariigi Valitsus (2022) Estonian Green Deal Action Plan (Eesti Rohepöörde Tegevusplaan).

Politics matters in sustainability.

In the European Union (EU), a wide range of legislative proposals, targets, organizations, and goals already exists across diverse countries. Upcoming laws aim to harmonize approaches to sustainability and raise standards for all member states, in turn influencing producers who wish to sell in the EU common market.

- (Anon, n.d.y) report: The EU has a ***taxonomy of environmentally sustainable economic activities*** published by the Technical Expert Group (TEG) on sustainable finance.

Taxes

- There have been proposal of a “meat tax”.

SDGs

- SDGs need to discussed in their totality Popkova et al. (2022).
- German Institute of Development and Sustainability (IDOS) connects SDGs to NDCs. Dzebo, Iacobuță & Beaussart (2023)
- International Energy Agency (IEAs), Decarbonisation Enablers IEA (2023b)

Sustainability Policy context is Shifting Around the World

- “In the context of the EU Plastics Strategy, the European Commission has launched a pledge to increase the use of recycled content to 10 million tons by 2025. To address this, Circularise Plastics Group launched an “Open Standard for Sustainability and Transparency” based on blockchain technology & Zero-knowledge Proofs” Circularise (2020b)

- “data-exchange protocol with privacy at its heart” Circularise (2020a)
- EU AI Law Lomas (2024)

European Green Deal

- Anon (2021a)
- Switch2Green (2023)

It's up to legislators to provide sustainable products on our marketplace... but until we do, use the green filter.

- One of the EU goals is reducing consumption
- Tacking our consumption habits
- Europe is the hotbed of sustainability
- Iman Ghosh (2020)
- Lamoureux (2018) Florida sustainable companies
- MICHAEL HOULIHAN & BONNIE HARVEY (2018) customers prefer sustainable companies
- Rajagopalan & Landrigan (2023): In the US, the *Inflation Reduction Act* provides funding to development of de-carbonizing technologies and includes plans to combat air pollution, reduce green house gases and address environmental injustices.

Kunming-Montreal Global Biodiversity Framework

Eco-Design is a Key EU Sustainable Policy Design Tool

A large part of the proposal by (Commission et al., 2014) is *eco-design*, as a large part of product lifecycle environmental impact is defined in the design process.

Table 22: Eco-design framework proposes 9 values to strive for in high quality products.

Quality		
Durable	Reparable	Easy to recycle
Reusable	Easy to maintain	Energy efficient
Upgradable	Easy to refurbish	Resource efficient

- The proposal for a Nature Restoration Law by the European Commission requiring member countries to restore 20% of EU's degraded ecosystems by 2030 and full restoration by 2050 has not yet passed Anon (2023ac) and is facing a backlash David Pinto (2023).
- Manzardo et al. (2021) (**need access!**)
- Iñarra et al. (2022) (**need access!**)
- Munaro, Tavares & Bragaña (2022) (**need access!**)
- Bassani et al. (2022) (**need access!**)
- Van Doorsselaer (2022) (**need access!**)
- (Nuez, Ruiz-García & Osorio, 2022) shows how electric vehicles may increase CO₂ emissions in some areas, such as Canary Islands, where electricity production is polluting.

- Rossi, Cappelletti & Germani (2022) shows how introducing sustainability early in the design process and providing scenarios where sustainability is a metric, it's possible to achieve more eco-friendly designs.
- Tiernan et al. (2022) microplastics are a real concern
- Arranz, Sena & Kwong (2022) developing circular economy is really complex
- Cheba et al. (2022)
- Ruiz-Pastor et al. (2022)
- Miyoshi et al. (2022) takes the example of ink toner bottles and shows in a case study how standardized compatibility between older and newer systems can save resources and results in sustainability savings.
- Finding green products and supporting companies making them
- Supporting legislative changes
- Track your consumption, saving, investing. Shift balance towards saving and investing.
- Nastaraan Vadoodi (2022)
- European Commission (2022b) Ecodesign for sustainable products

Europe From 2023 to 2030

- EU releases strategic foresight reports since 2020 (European Commission, 2023b).



Figure 6: EU Policy Context Timeline

We have an opportunity to re-imagine how every product can be an eco-product and how they circulate in our circular economy.

Timeline of the Policy Context:

- In 2019 by the von der Leyen commission adopted the European Union (EU) **Green Deal** strategy.
- In 2021 the Commission proposed a goal of reducing CO2e emissions by 55% by 2030 under the *Fit for 55* policy package consisting of a wide range of economic measures.

- In November 2022, the proposal was adopted by the EU Council and EU Parliament with an updated goal of 57% of CO₂e reductions compared to 1990. This proposal is set to become a binding law for all EU member countries (European Commission (2019b); European Commission (2019a); Anon (2022d); European Council (2022)).
- In March 2022, the EU Circular Economy Action Plan was adopted, looking to make sustainable products *the norm* in EU and *empowering consumers* as described in European Commission (2022a). Each product covered by the policy is required to have a **Digital Product Passport** which enables improved processing within the supply chain and includes detailed information to empower consumers to understand the environmental footprint of their purchases. It's safe to say the large majority of products available today do not meet these criteria.

Quality of Life

Wellbeing Economy Governments is an Example of Country-level Collaboration

- Finland, Iceland, New Zealand, Scotland, Wales, Canada (Fioramonti et al., 2022).
- Kaklauskas et al. (2023)
- Anon (2023am) Integrated science of wellbeing
- Fabris & Luburić (2022)
-

Design Implications

- Sustainability is part of product quality. If a product is hurting the environment, it's a low quality product.

TODO

- “triple turn”
- lack of transparency
- Call for GOP contributors’ transparency

Table 23: Implications

Category	Implication
Transparency	In unison, the reviewed technologies and practices move us closer to enabling <i>realtime ESG</i> : up-to-date transparent information about how our products are produced.
Speed	Realtime ESG is a building block to enable consumers and investors make more accurate, real-world purchase decisions.
Actionability	Simplify action
Pollution	<i>People live in the polluted areas are so used to it. What app to wake them up? “You live in a highly polluted area. Here’s the TOP 10 companies causing pollution. Here’s what you can do.”</i>

Health Tracking	Blood testing and biomarkers allow people to track their health. I'm introducing the concept of 'eco-markers' to follow the sustainability of human activities.
Circular Economy	AI can help us make sense of the vast amounts of sustainability data generated daily.
EPR	ERP and CDP data should be part of Green Filter.
Eco-Design	How to find eco-designed products?
CE and EPC	Encouraging Sustainable Design
Politics Matter	

Sustainable Design

Designing for Sustainability requires a higher level of systems thinking than traditional design methods. While AI allows us to look at a larger number of design scenarios than previously feasible, there are many approaches looking for ways to design for sustainability.

Eco-Design

Transformation towards *eco-design* has strong political support from the European Union. The Ecodesign for Sustainable Products Regulation (ESPR) legislation entered into force in the EU on July 18, 2024 (European Commission, 2024) following the (European Parliament, 2022) proposal in 2022 whereby the European Commission established a general framework for “*eco-design requirements for sustainable products, repealing rules currently in force which concentrate on energy-related products only,*” thus setting up the standards and a level playing-field for the organizations operating on the EU market. Virginijus Sinkevičius, the EU Commissioner for the Environment, Oceans and Fisheries, is quoted as describing eco-design “*respects the boundaries of our planet*” (European Commission, 2022c).

Approaches to Design for Sustainability

While the ESPR regulation chose *Eco-Design* as the overarching terminology, designing for sustainability has many names, with subtle differences of emphasis and nuance. Researchers and practitioners discuss *Circular Design*, *Cradle-to-Cradle Design*, *Green Design*, *Regenerative Design*, *Climate-Responsive Design*, *Life-Centered Design*, and others. In most cases, designing for sustainability makes use of *systems thinking*, underlining the importance of looking at the entire lifecycle of a product or service. Sustainable design encompasses all human activities, making this pursuit an over-arching challenge across all industries with the complex interdependencies within. (Ceschin & Gaziulusoy, 2016) gives a comprehensive overview of main the themes sustainable design and their main contributions and limitations in their well-researched “Evolution of design for sustainability: From product design to design for system innovations and transitions”. As this research is *practice-oriented* (i.e., my goal here is to find design approaches that could provide context for and at the end of the day - influence my prototype), I will refrain myself to looking at some key design fields which I find relevant to my project.

Human-Centered Design, the grandfather of design with attitude. Explain ISO9241-210, revised as ISO 9241-210:2019 user experience, iteration (Google Design, 2019). <https://www.iso.org/standard/77520.html>

Life-Centered Design recognizes human impact on our surrounding environment as well as non-human animals making sure to include them among stakeholders. While *Human-Centered Design* has become popular, the effect humans are having on biodiversity should be considered when designing. “[T]he design phase of a physical product accounts for 80% of its environmental impact” notes(Borthwick, Tomitsch & Gaughwin, 2022) in their framework for life-centered design.

Climate-Responsive Design embeds a building within the environmental constraints of a place and looks for opportunities use the land, wind, sun, local materials, and local vernacular history and culture when considering a design. Architect Susanne Brorson suggests sustainability should be

considered in the earlier phases of design instead of trying to fix problems later discussing *climate-responsive design principles* (EVM maaarhitektuuri keskus, 2019). The sentiment is echoed by (Lee & Doevedans, 2011) who edited a volume on sustainable approaches of world-renowned architects: “The principles of sustainable design are rooted in the building’s relationship to the site and its environmental conditions such as topography, vegetation, and climate.”

Biomimicry is about being inspired by nature while *Biodesign* focuses on design involving biology in the design itself. Janine Benyus, who coined the word *Biomimicry* (Benyus, 2009) looks at very practical cases of innovation where engineers and biologist meet and (Dicks, 2023) provides a much more philosophical account of following the example of nature. In a similar vein, *Material Ecology* is the wording preferred by the architect Neri Oxman based at the MIT Media Lab working with biomaterials as a proponent of *Nature-Centric Design* that adheres to the principles of ecological sustainability with both an ecologically conscious mindset and practical toolset (Hencz, 2022). Neri Oxman’s expressions in her (World Economic Forum, 2016) interview: “ecology-indifferent”, “naturing”, “mother naturing”, “design is a practice of letting go of all that is unnecessary”, “nature should be our single client” remind me how language shapes human thinking. Massachusetts Institute of Technology (MIT) is a source of many fantastic innovations, and another

Regenerative Design suggests dematerializing (digitizing) economies is not enough. Design should look for avenues to *regenerate* damaged or even completely destroyed natural systems – ecosystems, biodiversity, land, forests, lakes, rivers - natural habitats.

Durability is an important dimension for sustainability. High quality durable products are more sustainable as they last longer and less likely to be thrown away. Forming an emotional bond with the product makes it feel more valuable (Zonneveld & Biggemann, 2014). (Chapman, 2009) argues in his seminal paper (and later in his book) for “*Emotionally Durable Design*”, the simple idea that we hold to things we value and thus they are sustainable. We don’t throw away a necklace gifted to us by mom, indeed this object might be passed down for centuries. (Rose, 2015) has a similar idea, where “**Enchanted Objects**” become so interlinked with us, we’re unlikely to throw them away. This has implications for sustainability as the object is less likely to be thrown away.

As the above shows, there are many partially overlapping design words created by different people for diverse purposes. Design vocabulary may be created for distinguishing a particular type of design from another - or to market oneself as the creator of the word. Here I will use the lens of *sustainability* - another complex term - to look at how design can contribute to eco-friendly products.

Future Scenarios

Sustainability is fundamentally a hopeful word imbued with the dream a healthier world is possible.

Scenario-building is a key tool for sustainability. Because sustainability is so complex, sustainable design makes use of scenarios. *Life Cycle Assessment* and *Environmental Impact Analysis* are needed to provide eco-design scenarios (de Otazu et al., 2022).

Speculative Design makes use of future scenarios to envision contexts and interactions of use. First introduced by (Dunne & Raby, 2013) in their seminal book, the field aims to question the intersection of *user experience design* and *speculative fiction*. (Barendregt & Vaage, 2021) explores the potential of speculative design to stimulate public engagement; thought experiments can spur

public debate on an issue chosen by the designer. Phil Balagtas, founder of The Design Futures Initiative at McKinsey, discusses the value of building future scenarios at his talk at Google. His favorite example, the Apple Knowledge Navigator, first appeared in an Apple vision video in 1987 and took two decades to materialize in the real world. It was inspired by a similar device first shown in a 1970s episode of Star Trek as a *magic device* (a term from participatory design), which then inspired subsequent consumer product development. It took another two decades, until the launch of the iPhone in 2007 - a total of 40 years.

Participatory Design focuses on engaging users deep in the design process to truly understand their needs on a non-superficial level. For both speculative and participatory design, the cost makes it into a niche activity. Generative AI holds the promise to allow designers to dream up and prototype quicker. In order to build a future, it's relevant to imagine and critique a future. By being quickly generate prototypes, once can test out ideas with the future users involving more of the community and stakeholders. To be able to build something, one first needs to imagine it; imagination is crucial for change

Sustainability Begins in Software

Designing user interfaces for sustainable interactions means incorporating data and toolsets to enable designers to make decisions which reduce emissions of their design. Companies like AutoDesk are putting CO₂ calculations inside their design software, helping designers reduce material usage, energy consumption, CO₂ emissions, while increasing recyclability(Mike Haley, 2022). Software is key to building more sustainable products, already for decades (Gupta et al., 2023). AI-assisted design enables design for sustainability because the design process is where sustainability begins. AI has the potential to provide the parameters for sustainability. (Singh & Sarkar, 2023) proposes an AI tool for deciding the suitable life cycle design parameters.

Design encompasses most everything in our daily lives. Humans live in artificial environments where *most things* are designed by humans. The *experiences* we take part in are increasingly created based on some type of data.

- Involving young HCI designers in AI-oriented workshops can show the future of UI/UX ? (Battistoni et al., 2023)

Data is the interface between idle resources and retail demand, which makes *exchange of value* possible.

- Different Gets Ignored Luke Wroblewski (2024)

Digital Sustainability, information pertaining to emissions would flow through the economy not unlike the carbon cycle itself.

- Pan & Nishant (2023) important

Interaction Design for Climate Change: how can we change common UIs so they take into account sustainability?

- UIA World Congress of Architects (2023) “Design for climate adaptation”
- Andrew Chaisson (2019)
- Dzigajev (2019)

- Mankoff et al. (2007)
- Borthwick, Tomitsch & Gaughwin (2022)
- Lose (2023b) is worried about applying UX skills for Climate Change

AI-Assisted Design

Tool vs Assistant? (Tools are mostly non-anthropomorphic?). Tools do not call attention to themselves. They don't necessarily rely on human-like representations that call attention to themselves but rather are available in-context to help streamline specific tasks.

- September 16, 2020 (2020) "What is AI-assisted Design?"
- Clipdrop (n.d.) AI Design Assistants
- Architechtures (2020) Architecture with the help of AI
- Zakariya (2022) Canva image generator
- Kore.ai (2023) Kore.ai developing custom AI-chatbots for business usage.
- Anon (n.d.k) storytelling by AI

Data-Driven Design

Data-Driven Design Enables Sustainability. Sustainability touches every facet of human existence and is thus an enormous undertaking. Making progress on sustainability is only possible if there's a large-scale coordinated effort by humans around the planet. For this to happen, appropriate technological tools are required.

Data-driven design has limitations.

Platform Economy Growth

Platform economy companies popularized and expanded Data-Driven Design in the service of growth marketing (also known colloquially as growth hacking). Capturing User Data was part of this strategy which enabled improving the products. Digital Product Design is increasingly data-driven. Digital platforms operate a *design as a process* in a continuous feedback loop, where *measurements, experiments, predictive analytics and personalization* form a data-drive design culture. As we humans go about our daily business, governments and companies track our activities using various technologies, which produces massive amounts of user interaction data. Platform economy companies are the capture and use large amounts of data from users. Data is useful for designing better products. Designing for high retention (users keep coming back). Network Effects, the more people use a platform, the more valuable it becomes. Platforms that continuously add features (provided consumer legislation allows it) may eventually evolve into superapps, which are useful for providing services for a wide category of human needs. Bundling many services under one super-brand. Superapps are possible thanks to Nudge, Economies of Scale, Network Effects, Behaviour Design. Large Digital Platforms have a very small number of workers relative to the number of users they serve. This creates the necessity for using automation for both understanding user needs and providing the service itself. Creating a good product that's useful for the large majority of users depends on *Data-Driven Design*.

Design is as much about how it works as it's about the interface.

Digital product design can be seen as a specific discipline under the umbrella of Experience Design. In Michael Abrash (2017) Meta Oculus augmented reality incubation general manager Laura Fryer: “*People buy experiences, not technology.*”

Young people expect a product. Intelligent Interfaces use interaction design to provide relevant and personalized information in the right context and at the right time.

There are many approaches to design - from playful to practical to critical and to data-driven. Nonetheless, many types of design share a common goal designing for a good *user experience*. Simplifying.

Personalization: the largest businesses today (measured in number of users) design the whole user experience.

Scale, Popular consumer platforms strive to design solutions that feel personalized at every touch-point on the user journey (to use the language of service design) at the scale of hundreds of billions of users.

Superapps are honeypots of data that is used for many types of behavior modeling. (Suarez et al., 2021) suggests using alternative data from super-apps to estimate user income levels, including 4 types of data: Personal Information, Consumption Patterns, Payment Information, and Financial services. (Roa et al., 2021) finds super-app alternative data is especially useful for credit-scoring young, low-wealth individuals. The massive amounts of data generated by these companies are used by smart cities to re-design their physical environments.

Enablers of Platform		
Economics	Pros	Cons
Network effects	The more people use a platform, the more valuable it becomes both for the company and the user.	Data is not portable or difficult to migrate. You can't leave because you'll lose the audience. There's a lock-in effect.
Scalability		
Data-driven		
Design		
Behaviour		
Design		

- *Platform Economy* marketplace companies like Airbnb, Uber among many others match optimize how our cities work. Superapps are prevalent in China and South-East Asia. (Giudice, 2020) finds WeChat has had a profound impact on changing China into a cashless society, underlining how one mobile app can transform social and financial interactions of an entire country. China is the home of many superapps and (Vecchi & Brennan, 2022) discusses the strategies Chinese apps are taking to expand to other markets. (Shabrina Nurqamarani et al., 2020) discusses the system consistency and quality of South-East Asian superapps Gojek and Grab.
- Platform economy companies have been criticized for their lack of workers rights (ESG). (Anon, 2024g) uses portable air pollution tracking devices to documents how gig workers are subjected to pollution.
- Uber is creating an all-purpose platform; only 4.1% of rides were electric (Levy, 2023).

- X (formerly Twitter) is becoming a superapp?

Could there be Sustainability Superapps?

- How to design sustainability superapps? Lots of options in a single app. (Fleet Management Weekly, 2022) “Sustainability and superapps top Gartner’s Top 10 2023 Trends List”. (Dave Wallace, 2021) “The rise of carbon-centric super apps”. (goodbag, 2023) “goodbag: Sustainable Super App”. What would a sustainable investment platform that matches green investments with the consumers look like, if one saw the side-by-side comparison of investment vehicles on their ESG performance? Also (Bernard, 2022).
- Undheim (2024) Ecotech
- Lori Perri (2022)
- Anon (2022j)
- Anon (2021o) PayPal dominance
- Zeng (2015) (**need to pay for article!**)
- Huang & Miao (2021) (**need to pay for article!**)
- Anon (2022q)
- (Cuppini, Frapperti & Pirone, 2022) historical overview of the development of capitalism from linear **Fordism** through platform economy and logistics’ revolution which allows for circular economies to happen in a city.
- Adaptive AI

Open Data Sharing

Open Data Enables Collaboration

- Taiwan is a proponent of Open Gov OP-MSF OGP (Open Government Partnership, 2021; Lab, 2021)

Data-driven design requires access to data. making the movement towards *open data sharing* very important. Some countries and cities are better than others at sharing data openly.

Table 25: Examples of cities and countries that share data openly.

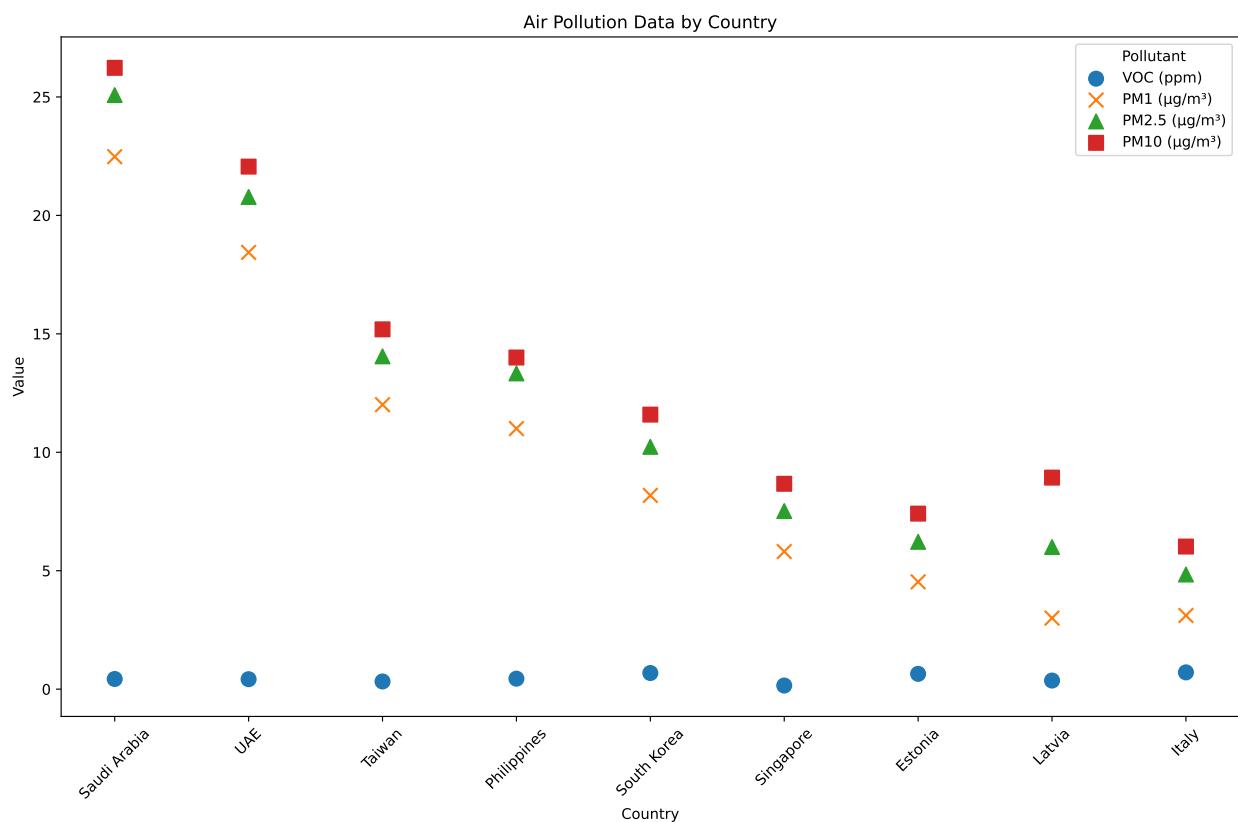
Country	Project	Reference
Sweden	Swedish open data portal	Anon (n.d.bq)

- When will Bolt show CO₂ emissions per every trip?
- Sustainable finance data platform:
- WikiRate (2021) WikiRate defines Data Sharing Archetypes

Type	Example
Transparency Accountability	
Advocate	
Compliance Data Aggregator	
Data Intelligence Hub	
Worker Voice Tool	Caravan Studios (2022): “ Worker Connect ”
Traceability tool	trustrace.com
Open data platform	
Knowledge sharing platform	business-humanrights.org

- WikiRate is a tool for checking green credentials Transparency
- Laureen van Breen et al. (2023)
- Wikirate (2022a)
- Anon (n.d.ai)
- Ray (2023) comprehensive overview of Web3.
- Rehash: A Web3 Podcast (2022) human-centered web3

Pollution Exposure Tracking



Health Tracking

Personal data enables behavior change.

While the scale of climate change is too big for individual action to make a difference, individual action can foster hope and a sense of collective responsibility (Nature, 2020).

- Kristian Steensen Nielsen (2022) **Individual climate action!!!**
- The UN has been handing out Global Climate Action Awards since 2011 for idea such as the Climate Credit Card in Switzerland, which automatically tracks emissions of purchases, creates emissions' reports for the user which can then be offset with investments in climate projects around the world (UNFCCC, 2023a).
- **Give Gen-Z the tools to turn climate anger into positive change to transform companies**
- Echeverría, Gimenez-Nadal & Molina (2022) suggests greener modes of mobility.
- Anon (2017b)
- Brantley (2021)
- Contact Kalle Lasn, Culture Jam
- “ESG Accessibility”, Large-scale accessibility to ESG,
- increase ESG accessibility
- Shop sustainability in Estonia (Lilleväli, 2022; Anon, n.d.w). Tarbimise jalajälg poes (Helen Saarmets, 2021). Offsets at the point of sale (Anon, n.d.ag).
- Green Finance Platform (2020) report predicts the rise of personalizing sustainable finance, because of its potential to grow customer loyalty, through improving the user experience. Similarly to good design, interacting with sustainable finance for the ‘green-minded’ demographics, providing a reliable green product is a way to build customer loyalty.

Research on Personal Data Tracking also known as *quantified self* or self-monitoring is abundant. Wearable devices including the Apple Watch, Oura Ring, Fitbit and others, combined with apps, help users track a variety of health metrics. Apart from health, wearable devices have been used to track other metrics such as physiological parameters of students at school to determine their learning efficiency (Giannakos et al., 2020).

Use technology Wearables to be more aware of one's health. Example of quantified self device. My personal air pollution exposure tracked using the Atmotube device attached to my backpack. Tracking air pollution and realizing how bad the over in my grandma's house is: add picture. Quantified Self is an example of Digital Health. There is a parallel in health to sustainability and indeed both are inextricably linked. Open Source code for calculating air pollution exposure AQI (Atmotech, 2024).

Could one track personal sustainability in a similar fashion? (Shin et al., 2019)'s synthesis review of 463 studies shows wearable devices have potential to influence behavior change towards healthier lifestyles. Saubade et al. (2016) finds health tracking is useful for motivating physical activity. The urban environment has an influence on health. Delclòs-Alió et al. (2022) discusses walking in Latin American cities. Walking is the most sustainable method of transport but requires the availability of city infrastructure, such as sidewalks, which many cities still lack.

EEG (electroencephalogram), ECG (Electrocardiogram), EDA (Electrodermal Activity): tracking features of brain, heart and nervous system activity. Brain Music Lab founder and brain researcher

Grace Leslie: “brain music sounds like a warm bathtub”. Tracking blood sugar with app and patches. Blood sugar trackers. Blood glucose tracking is popular even for people without diabetes, to optimize their activity (Anon, 2021k). Tracking urine consistency inside your toilet with WithThings. Companies like NeuralLink are building devices to build meaningful interactions from brain waves (EEG).

Apple is a leader in health tracking. In 2022 Apple outlined plans for “*empowering people to live a healthier day*” and Apple’s HealthKit provides a growing list of health metrics, which app developers can tap into (Apple, 2022a, 2022b). Liu et al. (2019) tracks how wearable data is used for tracking sleep improvements from exercise. Grigsby-Toussaint et al. (2017) made use of sleep apps to construct humans behaviors also known as *behavioral constructs*.

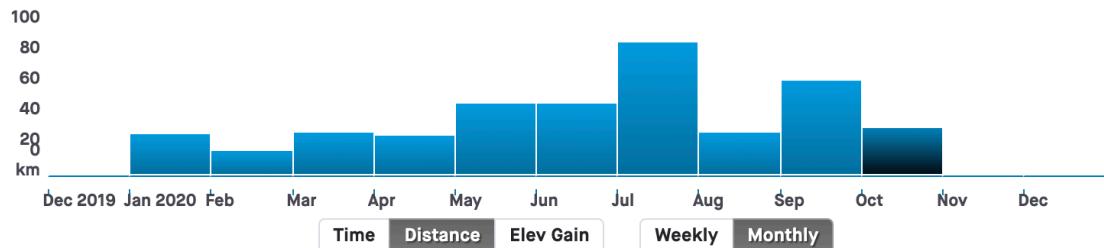
Another aspect is tracking one’s mental health. (Tyler, Boldi & Cherubini, 2022) surveys the use of self-reflection apps in the UK (n=998).

- Popular Strava (100+ million users) sports assistant provides run tracking and feedback (Strava, 2022).

Activities for Oct 2020

Dec 2, 2019 - Nov 30, 2020 ▾

30.4km | 3h 2m | 260m



Kris Haamer
October 25, 2020 at 7:45 PM



Evening run

12.11 km 5:28 /km 1h 6m 🏃 2
運河東向run PR (12:11)



Like 5 | Comment 0 | Share ▾



Kris Haamer
October 17, 2020 at 6:27 AM



Morning jog around the island

18.31 km 6:21 /km 1h 56m



+5

Like 9 | Comment 3 | Share ▾



[See all 3 comments](#)



Kris Haamer José Manuel Ferreira PT Sim, é! E me faz recordar

Figure 7: Popular Strava sports assistant provides run tracking and feedback

- AI Financial Advisors will need to go further to motivate users.
- DBS digibank app added a financial advisor named “Your Financial GPS” in 2018 DBS (2018)
- “urban metabolism” (Anon, 2021s; Claire Moran, 2018), city in-out flows accounting method
- Tsai et al. (2019)

- Burger, White & Yearworth (2019)
- Aromatario et al. (2019) behavior changes
- Ayoola et al. (2018) wellbeing data
- Godfrey et al. (2018)
- Thomas et al. (2018)
- Tonne et al. (2017)
- Anselma, Mazzei & De Michieli (2017)
- Forlano (2017) post-humanism and design
- Greenbaum & Gerstein (2016)
- Millings et al. (2015)
- Reis et al. (2015)
- Bower & Sturman (2015)
- Fletcher (2022)
- Ryan (2022) uses the “capability methodology” to evaluate if apps help people eat healthily.
- Baptista et al. (2022) apps for sleep apnea

Ceschin & Gaziulusoy (2016) shows how design for sustainability has expanded from a product focus to systems-thinking focus placing the product inside a societal context of use. For example Anon (n.d.i), recycled clothing maker FREITAG offers sustainability-focused services such as cargo bikes so you can transport your purchases and a network for *shopping without payment* = swapping your items with other members, as well as repairs of their products. Loaning terminology from ***service design***, the user journey within an app needs to consider each touchpoint on the way to a state of success.

Weinschenk (2011) says “*People expect most online interactions to follow the same social rules as person-to-person interactions. It’s a shortcut that your brain uses to quickly evaluate trustworthiness.*”

The small screen estate space of mobile phones and smart watches necessitates displaying content in a dynamic manner. Virtual reality glasses (called AR/VR or XR in marketing speak) need dynamic content because the user is able to move around the environment. These are questions that interaction design is called upon to solve. Hoang (2022): “*Dynamic interfaces might invoke a new design language for extended reality*”.

Speaking is one mode of interaction that’s become increasingly possible as machines learn to interpret human language.

Table 27: Modes of interaction

Mode of Interaction
Writing
Speaking

Mode of Interaction

Touching
Moving

Coputer

Humans respond well to **storytelling**, making **character design** and **narrative design** relevant to interaction design. Large language models (LLMs) such as ChatGPT are able to assume the personality of any character that exists inside of its training data, creating opportunities for automated narrative design.

One mode

- Konings (2020)
- “Digital sustainability principles”
- Eminent journal Design Studies, 1st design journal
- Part of digital product design are **design systems** to keep consistency across the experience.
Create a design system to best to showcase my analytic skills:
 - Design System: <https://zeroheight.com/8bf57183c/p/82fe98-introduction>
 - Anon (n.d.e)
 - Suarez et al. (n.d.)
 - Anon (n.d.av)
 - Anon (n.d.f)
- Kolko & Connors (2010) and IxDF (n.d.) believe interaction design is still an emerging (and changing) field and there are many definitions. I prefer the simplest version: interaction design is about creating a conversation between the product and the user.
- AI gives designers new tools. In AI development, design is called alignment. What is the role of an AI Designer? Linden (2021)
 - Anon (n.d.bf)
 - Anon (n.d.ar)
 - Parundekar (2021)
- Richard Yang (2021) and Justin Baker (2018) say some of the tools used by interaction designers include
- AI for design: Figma (2023)

The concept of **Social Objects** is People need something to gather around and discuss. SharingLab (2015): I’m interested in the concept of a “social object”.

Red Route Analysis is an user experience optimization idea inspired by the public transport system of London (Oviyam™, 2019; Anon, 2021j; Xuan, 2022).

- Product marketers focus on the **stickiness** of the product, meaning low attrition, meaning people keep coming back.
- What percent of all design is “sustainable design”? Promoting sustainable design.
- Josh Luber (2021) Trading cards are cool again
- Jesse Einhorn (2020)

- Connie Loizos (2021)
- Natasha Mascarenhas (2021)
- JEFF JOHN ROBERTS (April 23, 2020 at 2:00 PM GMT+3)

Narrative Design

- The rising availability of AI assistants may displace Google search with a more conversational user experience. Google itself is working on tools that could cannibalize their search product. The examples include Google Assistant, Google Gemini (previously known as Bard) and large investments into LLMs.
- Alethea AI (2021): discusses writing AI Characters, creating a personality.
- Writing as training data? large language models. GTP3.
- Stories start with a character.

Carbon Tracking

Personal carbon footprint tracking apps (aka CO2 calculators) in a mid-sized German city (N=216) helped overall emission reduction by 23% correlating with feedback from the app specifically reducing emissions from heating 26.9%, food 16.4%, household 34.7% reduction, and mobility 12% (Hoffmann et al., 2024).

We have a limited carbon budget so calculating CO2e-cost become integrated into every activity.

- CO2e calculations will be part of our everyday experience
- Personal carbon footprint calculators have been released online, ranging from those made by governments and companies to student projects.
- Zhang's Personal Carbon Economy conceptualized the idea of carbon as a currency used for buying and selling goods and services, as well as an individual carbon exchange to trade one's carbon permits (Zhang, 2018).

Personal Carbon Trackers

Similar to personal health trackers, personal CO₂ trackers help one track emissions and suggests sustainable actions.

Table 28: A selection of personal sustainability apps. See *greenfilter.app* for an updated database.

App	Description
Commons (Formerly Joro)	Financial Sustainability Tracking + Sustainable Actions
Klima	Offset Subscription
Wren	Offset Subscription
JouleBug	
eevie	
Aerial	
EcoCRED	
Carbn	

App	Description
LiveGreen Earth Hero	

Does Individual Climate Action Matter?

Does Individual Climate Action is Ineffective.

The effect of individual climate action is limited.

Data Privacy

Sustainability needs to be balanced with privacy.

- Sanchez et al. (2022) suggests tracking users using their smartphones and attributing points for actions deemed beneficial yet this has potentially privacy issues.

Behavioral Design

For decades, marketers and researchers have been researching how to affect human behavior towards increasing purchase decisions in commerce, both offline and online, which is why the literature on behavioral design is massive. One of the key concepts is *nudge*, first coined in 2008 by the Nobel-winning economist Richard Thaler; nudges are based on a scientific understanding of human psychology and shortcuts and triggers that human brains use and leverages that knowledge to influence humans in small but powerful ways (Thaler & Sunstein, 2009).

The principles of nudge have also been applied to sustainability. For example, a small study ($n=33$) in the Future Consumer Lab in Copenhagen by (Perez-Cueto, 2021) found that designing a “dish-of-the-day” which was prominently displayed helped to increase vegetarian food choice by 85%. Experiments by (Guath, Stikvoort & Juslin, 2022) focused on environmentally friendly online purchases in Sweden ($n=200$) suggest nudging can be effective in influencing online shopping behavior towards more sustainable options. A study of behavior change in Australia at large university setting ($N = 156$) by (Novoradovskaya et al., 2021) found nudging behavioral change had a significant effect and the author suggested it may help to avoid some of the “*16 billion paper coffee cups are being thrown away every year*” globally (based on the abstract - I was unable to access the full paper).

Google uses nudges in Google Flights and Google Maps, which allow filtering flights and driving routes by the amount of CO₂ emissions, as well as surfacing hotels with Green Key and EarthCheck credentials, while promising new sustainability features across its portfolio of products (Sundar Pichai, 2021). Such tools are small user interface nudges which Google’s research calls *digital decarbonization*, defined by (Implement Consulting Group, 2022) as “*Maximising the enabling role of digital technologies by accelerating already available digital solutions*”.

In (Kate Brandt & Matt Brittin, 2022), Google’s Chief Sustainability Officer Kate Brandt set a target of “at least 20-25%” CO₂ emission reductions in Europe to reach a net-zero economy and the

global announcement set a target of helping 1 billion people make more sustainable choices around the world (Jeni Miles, 2022). In addition to end-users, Google offers digital decarbonization software for developers, including the Google Cloud Carbon Footprint tool and invests in regenerative agriculture projects (Anon, 2021i; Google, 2023).

Google VERY IMPORTANTT Google (2021). Justine Calma (Oct 6, 2021, 10:01 AM GMT+3) Google UX eco features. Anon (2021g) Google green routes. Sarah Perez (2022) shows how google added features to Flights and Maps to filter more sustainable options. How CO₂ is shown by Google starts hiding emissions? Anon (2022f)

Table 29: Examples of CO₂ visibility in Google's products.

Feature	Product	Nudge
Google Maps AI suggests more eco-friendly driving routes Mohit Moondra (n.d.)	Google Maps	Show routes with lower CO ₂ emissions
Google Flights suggests flights with lower CO ₂ emissions	Google Flights	Show flights with lower CO ₂ emissions
Wizzair Check carbon impact Anon (n.d.bb)	WizzAir	Offset on Checkout

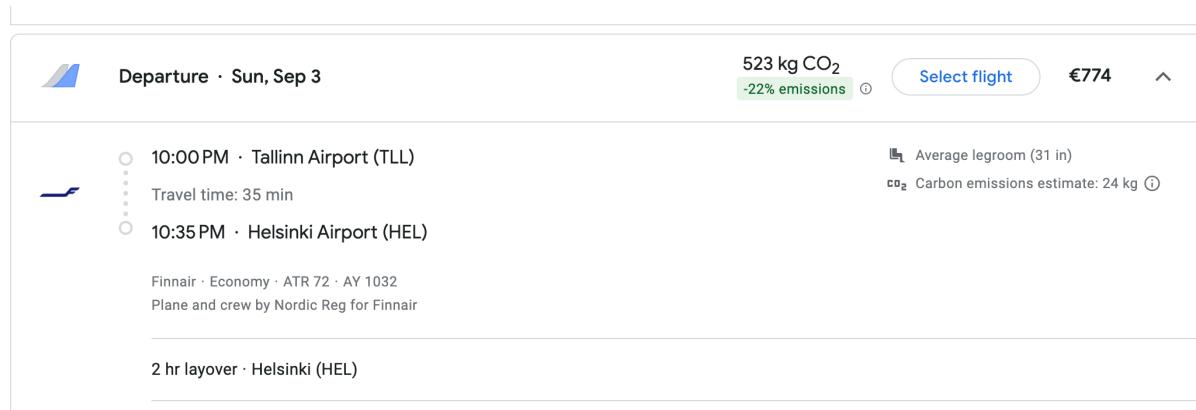


Figure 8: Google's view of flight emissions

- The founder of the Commons (Joro) consumer CO₂ tracking app recounts how people have a gut feeling about the 2000 calories one needs to eat daily and daily CO₂ tracking could develop a gut feeling about one's carbon footprint (Jason Jacobs, 2019).

Some notable examples:

- Eriksson, Christensen & Malefors (2023) discusses best practices for reducing food waste in Sweden.
- Acuti, Lemarié & Viglia (2023) makes the point that physical proximity to a drop-off point helps people participate in sustainability.
- Wee, Choong & Low (2021) proposes types of nudging technique based on an overview of 37 papers in the field.

Table 30: Types of nudge by Wee, Choong & Low (2021)

Name	Technique
Prompting	Create cues and reminders to perform a certain behavior
Sizing	Decrease or increase the size of items or portions
Proximity	Change the physical (or temporal) distance of options
Presentation	Change the way items are displayed
Priming	Expose users to certain stimuli before decision-making
Labelling	Provide labels to influence choice (for example CO ₂ footprint labels)
Functional	Design the environment and choice architecture so the desired behavior is
Design	more convenient

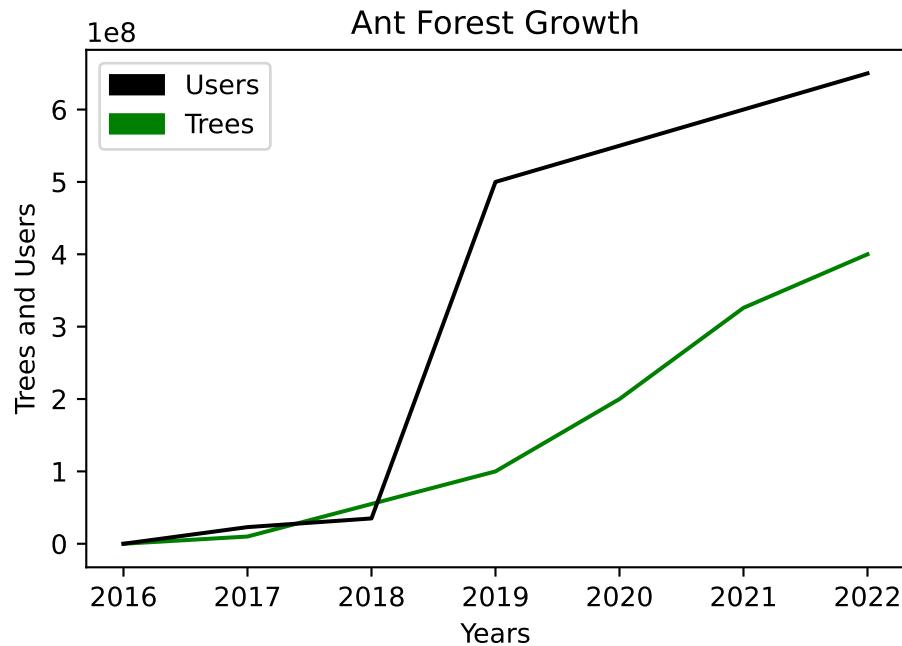
- Bain et al. (2012) “Promoting pro-environmental action in climate change deniers” (**Need access!**)
- Allcott (2011) “Social norms and energy conservation” (**Need access!, ncku doesn’t subscribe**)
- Schuitema & Bergstad (2018) “Acceptability of Environmental Policies” (**Need access!**)
- Nilsson et al. (2016) “The road to acceptance: Attitude change before and after the implementation of a congestion tax” (**Need access!**)
- Berger, Lange & Stahl (2022) (**Need access!**)
- Anon (2022m)
- United Nations Conference on Trade and Development (last) (2023)
- Climatiq (2023) Automate GHG emission calculations
- EarthCheck (2023) sustainable tourism certification
- LFCA (2023) corporate climate action
- Greenhouse Gas Protocol (2023) standards to measure and manage emissions
- Playing for the Planet Alliance (2021)
- Gamification makes uses of nudges.
- Students in Indonesia enjoy using Kahoot and it’s gamification elements are perceived to have positive impact on individual learning outcomes so they are happy to continue using it (Wirani, Nabarian & Romadhon, 2022).
- Anon (n.d.bn) game company going green

Gamification

- Alibaba’s Ant Forest (螞蟻森林) has shown the potential gamified nature protection, simultaneously raising money for planting forests and building loyalty and brand recognition for their sustainable action, leading the company to consider further avenues for gamification and eco-friendliness.

Table 31: Table of Ant Forest assisted tree planting; data compiled from (李连环 & 姜舒译, 2017; Yang et al., 2018; UNFCCC, 2019; Wang & Yao, 2020; Anon, 2021m; Zhang, Hu & Gu, 2022; Wang, Ibrahiem & Li, 2022; Zhou, Lin & Mou, 2023; Cao & Liu, 2023).

Year	Users	Trees	Area
2016	?	0	
2017	230 million	10 million	
2018	350 million	55 million	6500 acres??
2019	500 million	100 million	112,000 hectares / 66, 000 hectares?
2020	550 million	200 million	2,7 million acres?
2021	600 million	326 million	
2022	650 million	400 million	2 million hectares



Re-Designing Industries

We're in an industrial revolution. Many companies are investing into transforming their processes. “[T]ransition to a low carbon economy presents challenges and potential economic benefits that are comparable to those of previous industrial revolutions” (Pearson & Foxon, 2012). It's possible to re-design entire industries and that is exactly the expectation sustainability sets on businesses. Across all industries, there's a call for more transparency. Conversations about sustainability are too general and one needs to look at the specific sustainability metrics at specific industries to be able to design for meaningful interaction. There's plentiful domain-specific research showing how varied industries can develop eco-designed products. I will here focus on 3 industries that are relevant for college students.

Food and clothes (I'm omitting housing and transport here) are part of the immediate environmental impact of college students.

- 5th industrial revolution, advanced robotics
- 6th industrial revolution, quantum computing, nanotechnology Chourasia et al. (2022)
- 7th industrial revolution futurists are looking at current trends and building scenarios for 2050 envisioning a world where the convergence of bio-based and mineral-based technologies, widespread sustainability and energy-abundance (Ruiz Estrada, 2024).

...for Provenance and Traceability

Companies like Qima provide inspection and certification services <https://www.qima.com>

Clothes

Young people are the largest consumers of fast fashion (Anon, n.d.ca). (In European Environment Agency, 2022 European Environment Agency (EEA)) estimates based on trade and production data that EU27 citizens consumed an average 15kg of textile products per person per year. The European Commission wants to reduce the impact of fast fashion on EU market (ERR, 2022). (Millward-Hopkins, Purnell & Baurley, 2023) shows how 50% of the textile waste in the UK is exported to other countries.

“26 million tons of clothing end up in China’s landfills each year, propelled by fast fashion” (Tian Macleod Ji, 2024).

Greenwashing is prevalent in the fashion industry. **Problem:** Emily Chan (2022a) report says there's not enough transparency in fashion. Fashion Revolution Foundation (2022) Fashion transparency index. (Wikirate, 2022b): “Among the Index’s main goals are to help different stakeholders to better understand what data and information is being disclosed by the world’s largest fashion brands and retailers, raise public awareness, educate citizens about the social and environmental challenges facing the global fashion industry and support people’s activism”. Consumer understanding of sustainability is limited. Mabuza, Sonnenberg & Marx-Pienaar (2023) shows consumer knowledge of apparel coloration is very limited.

2.4 Trillion USD fashion industry contributing 2%-8% of total global GHG emissions, 100B USD lost to lack of recycling, contributes 9% of microplastics (Adamkiewicz et al., 2022). (Centobelli et al., 2022) Fashion industry year uses 9B cubic meters of water, 1.7B tonnes of CO₂, 92 million tonnes of textile waste. Köhler et al. (2021) Globally 87% of textile products are burned or landfilled after 1st consumer use.

- There are local policy initiatives aiming to tackle the waste problem. For example the New Standard Institute’s proposed “Fashion Act” to require brands doing business in New York City to disclose sustainability data and set waste reduction targets (Emily Chan, 2022b) .
- (Leung & Luximon, 2021) There’s a growing know-how on how to produce sustainably and which materials to use. “Handbook of Footwear Design and Manufacture” Chapter 18 - Green design. Industry collaboration can raise the bar for everyone, such as the Better Cotton Initiative (Better Cotton, 2023).
- Story of Patagonia (Chouinard, 2005)].

Sustainable Fashion, Textile Design

- There are signs of young Chinese consumers valuing experiences over possessions (Jiang, 2023).

Across industries, reports are saying there isn't enough transparency.

- (Hannah Ritchie, 2020; US EPA, 2016) GHG emission inventory by sector
- Marrucci, Marchi & Daddi (2020) Italian retail supermarkets carbon footprint?
- Gyabaah et al. (2023) research across several dumpsites across Ghana revealed up to 12% of the landfill consisted of textile waste.
- imperfectidealist (2020) Fashion sustainability vs greenwashing
- Anon (2023ah) Ethical Shopping
- Anon (2023ad) Ethical brand?
- Good On You (2023) Sustainable fashion company evaluations
- Anon (n.d.at) Garment Worker's rights
- Emily Chan (2022c): fashion companies can't be held accountable for their actions (or indeed, their lack of action).
- WikiRate (2023)
- Anon (2022g): "Political consumerism", "Instant Gratification for Collective Awareness and Sustainable Consumerism"
- FashionChecker (2023)
- Eesti Disainikeskus I Estonian Design Centre (2021) Circular textiles
- Eesti Kunstiakadeemia (2022) Sustainable Fashion education
- Anon (n.d.l)
- "The mainstream fashion industry is built upon the exploitation of labor, natural resources and the knowledge of historically marginalized peoples."
- Anon (n.d.br)
- "Secrecy is the linchpin of abuse of power...its enabling force. Transparency is the only real antidote." Glen Greenwald, Attorney and journalist.
- Stand.earth (2023)
- Anon (n.d.ay)
- Anon (n.d.g) Bangladesh Garment Manufacturers and Exporters Association
- Minimize shopping, buy quality, save CO₂, invest.
- Textile Exchange (2023) Ethical fashion materials matter
- Textile Exchange (2021): Policy request

- Free clothes
- Vanish UK (2021) “Generation rewear” documentary, sustainable fashion brands
- Storbeck (2021) and Remington (2020): Zalando says Fast fashion must disappear
- Infiniti Fiber (2023)
- Cleantech Group (2023) Global cleantech 100
- Anon (2023ae) Alterations and repairs made easy
- Anon (2023l) Ethical brand ratings

Food

Re-designing industrial food systems for an increasing global population is a challenge. Supply chain innovation in food industries may enable more transparency. **provenance and traceability of food has implications for sustainability and health.**

Global warming leading to droughts and extreme weather, wars and conflicts increased volatility in food prices (Eshe Nelson, Ana Swanson & Jeanna Smialek, 2023).

“The agricultural sector contributes to approximately 13.5% of the total global anthropogenic greenhouse gas emissions and accounts for 25% of the total CO₂ emission” (Nabipour Afrouzi et al., 2023). Poore & Nemecek (2018) suggests 26% of carbon emissions come from food production. Saner et al. (2015) reports dairy (46%) and meat and fish (29%) products making up the largest GHG emission potential. Springmann et al. (2021) proposes veganism is the most effective decision to reduce personal CO₂ emissions.

Farm to Fork is a European Union policy to shorten the supply chain from the producer to the consumer and add transparency to the system. Patel et al. (2023) livestock products (meat) are 15% of agricultural foods valued at €152 billion in 2018 globally.

- Farm to Fork Financial Times (2022)

Fishing

- 75% of fishing is done using industrial Trawling, which has environmental impact
- Complex supply chains make seafood (marine Bivalvia, mollusks) logistics prone to fraud, leading to financial losses and threats to consumer health (Santos et al., 2023). (Chang et al., 2021) *fish fraud* is a large global problem but it’s possible to use DNA-tracking to prove where the fish came from. In “2019, the 27 KURA SUSHI branches in Taiwan sold more than 46 million plates of sushi. in Taiwan”. Illegal, unreported and unregulated fishing (IUU) fishing is widespread; the EU is adopting countermeasures (Kim & Lim, 2024). Muñoz et al. (2023) Is there such a thing as sustainable fishing? Bottom trawling is the worst and should be banned. Katie Gustafson (2022) proposes a **“Uniform traceability system for the entire supply chain”** for seafood. Mamede et al. (2022) proposes *Seafood tracing*: Fingerprinting of Sea Urchin.
- The same is true for cocoa beans, which are at risk from food fraud (Fanning et al., 2023).

- **Perennial Crops**, Multi-year crops reduce inputs of gasoline, labor, etc. (Aubrey Streit Krug & Yin Lu, 2023). Large agritech companies like Monsanto rely on selling seeds annually for profits putting them at odds with **Perennial crops**. Single-year seeds have led to farmer suicides when crops fail in poor communities.
- Sustainability Accounting Standards Board, part of the International Financial Reporting Standards Foundation
- Global Reporting Initiative
- Anon (2022l)
- Anon (2021n) “Real Time ESG Tracking From StockSnips”
- Waters (2015) (**Need access!**)
- Cawthorn & Hoffman (2016) (**Need access! ncku doesn't subscribe**)
- Gamborg & Jensen (2017) (**Need access!**)
- Neethirajan & Kemp (2021) using biometric sensors to track livestock sustainability.
- Inc (n.d.)
- Tim Nicolle (2017)
- EAT-Lancet diet

Culture, Community, Cuisine, Storytelling

- Tsing (2015) mushrooms
- Food is about enticing human imagination and taste buds. Potato used to be a newcomer and innovative crop in Europe, and now it's so common, Europeans forget it's originally from Europe. Food is also about cuisine and culture; foods become popular if we hear stories and see cuisine around a particular crop (Aubrey Streit Krug & Yin Lu, 2023).
- IARC warns aspartame (artificial sweetener found in many soft drinks) could cause cancer [ADD CITATION].
- Yap et al. (2023) Singapore disposes of 900,000 tonnes of plastic waste out of which only 4% is recycled.
- Kiessling et al. (2023) Single-use plastics make up 44-68% of all waste mapped by citizen scientists.

Food Waste

There are several initiatives to reduce food waste by helping people consume food that would otherwise be thrown away.

Table 32: Food saving apps

Name	
Karma	
ResQ Club	(Kristina Kostap, 2022) ResQ Club in Finland and Estonia for reducing food waste by offering a 50% discount on left-over restaurant meals before they are thrown away.

Name	
Kuri Social media groups (no app)	Haje Jan Kamps (2022) Less impact of food

- Röös et al. (2023) identified 5 perspectives in a small study ($n=106$) of views on the Swedish food system:

Table 33: Perspective on food systems in Sweden.

Perspective	Content
“The diagnostic perspective”	“All hands on deck to fix the climate”
“The regenerative perspective”	“Diversity, soil health and organic agriculture to the rescue”
“The fossil-free perspective”	“Profitable Swedish companies to rid agriculture and the food chain of fossil fuel”
“The consumer-driven perspective”	“A wish-list of healthy, high-quality and climate-friendly foods”
“The hands-on perspective”	“Tangible solutions within the reach of consumers and the food industry”

- “regenag”, Václav Kurel, we need help consumers demand regenerative agriculture Baltic Sea Action Group (2023)
- Kommenda et al. (2022) Carbon Food Labels
- Food Sovereignty: “The global food sovereignty movement, which had been building momentum since its grassroots conception in the late ’90s, quickly gained traction with its focus on the rights of people everywhere to access healthy and sustainable food. One of the pillars of the movement lies in using local food systems to reduce the distance between producers and consumers.”
- CAITLIN STALL-PAQUET (2021): “We can grow foods just as well in the inner city as we can out in the country because we’re agnostic to arable land,” says Woods. “Because we grow indoors and create our own weather, [climate change] doesn’t affect our produce.”
- Renée Salmonsen (2018): Vertical farm in Taoyuan
- Catherine Shu (2023): *Intensive Farming Practices vs Farm to table*
- Akshat Rathi (2021) and Lowercarbon Capital (2023) climate startup funding.
- Only make what is ordered.

Circular Economy

Circular economy is a tiny part of the world economy. (Circle Economy, 2022) reports only 8.6% of world economy is circular and *100B tonnes of virgin materials* are sourced every year.

Encouraging Sustainable Design and Reducing Waste.

(Liu et al., 2023b) reports, e-waste is growing 3%-5% every year, globally. (Thukral & Singh, 2023) identifies several barriers to e-waste management among producers including lack of awareness and infrastructure, attitudinal barriers, existing *informal* e-waste sector, and the need for an e-waste license.

- McDonough & Braungart (2002) from Cradle to Grave book was released over 2 decades ago, change is slow.
- McGinty (Thu, 08/06/2020 - 11:25): How to Build a Circular Economy
- Dull (2021) book, many current technological hurdles can be overcome by supply chain professionals who are experts in connecting supply streams.

also known as circular economy. Assuming that as individuals we want to act in a sustainable way, how exactly would be go about doing that?

...for Sustainable Products

How can design enable/help/encourage sustainability?

- Use imagination
- Societal movements change things: implication for design: build a community
-
- Growing public understanding of how nature works and intersects with our use of money.
- Hedberg & Šipka (2021) argues digitization and data sharing is a requirement for building a circular economy.
- “Circular Petrochemicals” Lange (2021)
- Supply chain transparency enables stakeholder accountability (Circularise, 2018; Doorey, 2011; Fox, 2007).
- Recycling Critical Raw Materials, digitization of mining allows enhance the reliability of supply chains (CRM Alliance, 2020).
- EIT RawMaterials

Circular Design

Circular design is only possible if supply chains become circular as well.

It's important in which structure data is stored, affecting the ability to efficiently access and manage the data while guaranteeing a high level of data integrity, security, as well as energy usage of said data.

The complexity of resource and delivery networks necessitates more advanced tools to map supply chains (Knight et al., 2022). The COVID19 pandemic and resulting blockages in resource delivery highlighted the need to have real-time visibility into supply chains (Finkenstadt & Handfield, 2021).

Blockchains are a type of shared database where the data is stored in several locations with a focus on making the data secure and very difficult to modify after it's been written to the database. Once data is written to the blockchain, modifying it would require changing all subsequent records in the chain and agreement of the majority of validators who host a version of the database. Blockchain is the main technology considered for accounting for the various inputs and complex web of interactions between many participants inside the supply chain networks. There are hundreds of papers researching blockchain use in supply chain operations since 2017 (Dutta et al., 2020). Blockchains enable saving immutable records into distributed databases (also known as ledgers). It's not possible to (or extremely difficult) to change the same record, only new records can be added on top of new ones. Blockchains are useful for data sharing and auditing, as the time and place of data input can be guaranteed, and it will be easier to conduct a search on who inputted incorrect data; however the system still relies on correct data input. As the saying goes, "*garbage in, garbage out*".

There are several technologies for tracking goods across the supply chain, from shipping to client delivery. Data entry is a combination of manual data input and automated record-keeping facilitated by sensors and integrated internet of things (IoT) capabilities. For example (Ashraf & Heavey, 2023) describes using the Solana blockchain and Sigfox internet of things (IoT) Integration for supply chain traceability where Sigfox does not need direct access to internet but can send low powered messages across long distances (for example shipping containers on the ocean). (Van Wassenaer et al., 2023) compares use cases for blockchains in enhancing traceability, transparency and cleaning up the supply chain in agricultural products.

- Several startups are using to track source material arriving to the factories and product movements from factories to markets.
- Wagenvoort (2020) Self-driving supply chains.. (contact Japanese factory?)

Table 34: Blockchain supply chain companies as of summer 2023 include.

Company	Link	Literature	Comments
Ocean Protocol	oceanprotocol.com		
Provenance	provenance.io		
Ambrosius	ambrosus.io		
Modum	modum.io		
OriginTrail	origintrail.io		

Company	Link	Literature	Comments
Everledger	everledger.io		
VeChain	vechain.org		
Wabi	wabi.io		
FairFood	fairfood.org		
Bext360	bext360.com		
SUKU	suku.world	Miller (2019) SUKU makes supply chains more transparent	Seems to have pivoted away from supply chains

- Oikos Denktank (2021) circular material procurement requires new skills. How to reuse old paint? Small projects can have large social impact.
- For example, Duriez et al. (2022) shows how simply by reducing material weight it's possible to design more sustainable transportation.
- Embodied Carbon
 - “embodied carbon”
 - Carbon Neutral Cities Alliance
 - Builders for Climate Action (2021)

Tracking Transport Supply Chains

Products are made from resources distributed across the planet and transported to clients around the world which currently causes high levels (and increasing) of greenhouse gases. “*Transport greenhouse gas emissions have increased every year since 2014*” (Anon, 2023d). Freight (transport of goods by trucks, trains, planes, ships) accounts for 1.14 gigatons of CO₂ emissions as per 2015 data or 16% of total international supply chain emissions (Wang et al., 2022).

Table 35: Share of CO₂ of CO₂ emissions by type of transport globally (Statista & IEA, 2022).

Type of Transport	Percentage
Passenger cars	39%
Medium and heavy trucks	23%
Shipping	11%
Aviation	9%
Buses and minibuses	7%
Light commercial vehicles	5%
Two/three-wheelers	3%
Rail	3%

- Platzer (2023), a scientist working on the Apollo space program, calls for emergency action to develop *green aviation*.
- The California Transparency in Supply Chains Act which came into effect in 2012 applies to large retailers and manufacturers focused on pushing companies to eradicate human trafficking and slavery in their supply chains.
- The German Supply Chain Act (Gesetz über die unternehmerischen Sorgfaltspflichten zur Vermeidung von Menschenrechtsverletzungen in Lieferketten) enacted in 2021 requires com-

panies to monitor violations in their supply chains (Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung, 2023; Stretton, 2022b).

Ethics & Cruelty

Can data transparency provide tools for reducing cruelty.

- Traceability and animal rights. Animal rights vs animal welfare. Ethereum blockchain and animal rights. “Blockchain can provide a transparent, immutable record of the provenance of products. This can be especially useful for verifying claims made about animal welfare. For example, products claiming to be “free-range,” “organic,” or “sustainably sourced” could have their entire lifecycle recorded on the blockchain, from birth to shelf, allowing consumers to verify these claims.”
- Cruelty free brands
- BCorp
- ESG
- Trash found in ocean / nature etc
- Increase your investment point by matching with your contribution / .
- Point of Sales integration (know the SKU you buy). Integrate to the financial eco footprint (no need to scan the product). What’s the name of the startup that does this?
- Precision Fermentation and Cultivated Meat: Meat products without farm animals

Factories Can Become More Transparent

- Regional supply chains for decarbonising steel: “co-locating manufacturing processes with renewable energy resources offers the highest energy efficiency and cost reduction” Japanese-Australia study (Devlin & Yang, 2022).
- Transparency about the polluting factories where the products come from.. the product journey
 - virtual factories
- Tracing emissions from factory pipes... what’s the app?
- Factories should be local and make products that can be repaired.
- Carbon-neutral factories “made in carbon-neutral factory” list of products
- Stefan Klebert (2022)
- VDI Zentrum Ressourceneffizienz (2020)
- Anon (n.d.n) and Anon (n.d.am) CO₂ neutral factories?
- (Anon, n.d.au; Anon, n.d.r) CO₂ neutral websites
- Eric fogg (2020) Lights-Out Manufacturing
- Mowbray (2018) “World’s first free digital map of apparel factories”
- Anon (n.d.aa) Factory compliance - Fair Factories

- Planet Factory
- Anon (n.d.bv) Plastic waste makers index, sources of plastic waste

Extended Producer Responsibility

Extended Producer Responsibility Enables Companies to be Responsible.

Popular blogs such as (Kohli, 2019) and (Lose, 2023a) offer many suggestions how designers can help people become more sustainable in their daily lives yet focusing on the end-user neglects the producers' responsibility (termed as Extended Producer Responsibility or ERP) in waste management studies.

Extended Producer Responsibility (EPR) is a policy tool first proposed by Thomas Lindhqvist in Sweden in 1990 [ADD CITATION], aimed to encourage producers take responsibility for the entire life-cycle of their products, thus leading to more eco-friendly products. Nonetheless, EPR schemes do not guarantee circularity and may instead be designed around fees to finance waste management in linear economy models (Christiansen, Hasse & Tønder, 2021). The French EPR scheme was upgraded in 2020 to become more circular (Jacques Vernier, 2021). In July 2024, Latvia was the 4th EU country to join an textile-EPR scheme (Anon, 2024e).

In any case, strong consumer legislation (such as EPR) has a direct influence on producers' actions. For example, in HKTDC Research (2022), the Hong Kong Trade Development Council notified textile producers in July 2022 reminding factories to produce to French standards in order to be able enter the EU market. Peng, Shi & Tong (2023) finds that the *Carbon Disclosure Project* has been a crucial tool to empower ERP in Chinese auto-producers.

- The success of EPR can vary per type of product. For car tires, the EPR scheme in the Netherlands claims a 100% recovery rate Campbell-Johnston et al. (2020).

One type of legislation that works?

- (Steenmans & Ulfbeck, 2023) Argues for the need to engage companies through legislation and shift from waste-centered laws to product design regulations.
- In Europe, there's large variance between member states when it comes to textile recycling: while Estonia and France are the only EU countries where separate collection of textiles is required by law, in Estonia 100% of the textiles were burned in an incinerator in 2018 while in France textiles are covered by an Extended Producer Responsibility (EPR) scheme leading to higher recovery rates (Ibid).
- Greyparrot AI to increase recycling rates (Natasha Lomas, 2024).

Return, Repair, Reuse

- There's a growing number of companies providing re-use of existing items.
- Anon (n.d.bk) For example, Swap furniture in Estonia

Bring back your bottle and cup after use.

- Ruiz-Pastor & Mesa (2023) proposes a **product repairability index (PRI)**
- Formentini & Ramanujan (2023)

- Recycling (Lenovo, 08-29-22) “rethinking product design and inspiring consumers to expect more from their devices”
- “design is a tool to make complexity comprehensible” like the Helsinki chapel. there’s either or a priest or a social worker. it’s the perfect public service. “limit the barrier of entry for people to discover”. elegant.
- Zeynep Falay von Flittner (n.d.)

Packaging is a rapidly growing industry which generates large amounts of waste Ada et al. (2023). Bradley & Corsini (2023): “Over 161 million tonnes of plastic packaging is produced annually.”

- Anon (2022a)
- Anon (2022k)
- Anon (2010)
- (Lerner, 2019) Coca Cola plastic pollution. ESG ratings have faced criticism for lack of standards and failing to account for the comprehensive impact a company is having. (Foley et al., 2024) notes how Coca Cola fails to account the supply chain water usage when reporting becoming “water neutral” and calls on companies to release more detailed information.
- Anon (n.d.bo)

Digital Product Passports

CO_{2e} labeling initiatives are an early form of communicating the environmental cost of each product. Using carbon labels to communicate CO_{2e} emission of consumer products has been a topic of discussion for decades (Adam Corner, 2012). Academic literature has looked at minute details such as color and positioning of the label (Zhou et al., 2019). There’s some indication consumers are willing to pay a small premium for low- CO_{2e} products; all else being equal, consumers choose the option with a lower CO_{2e} number (Xu & Lin, 2022; Carlsson, Kataria & Lampi, 2022). (Cohen & Vandenberg, 2012) argues labeling the carbon footprint of products does help inform consumer choice towards sustainability and help promote a green economy. A large-scale study of UK university students finds some evidence to suggest labeling low CO_{2e} food enables people to choose a *climatarian diet*, however the impact of carbon labels on the market share of low-carbon meals is negligible (Lohmann et al., 2022).

Labels alone are not enough. A study in Sweden underlines a negative correlation between worrying about climate impact and interest in climate information on products (Edenbrandt & Lagerkvist, 2022). This latter finding may be interpreted to suggest a need for wider environmental education programs among consumers. (Asioli et al., 2022) found differences between countries, where Spanish and British consumers chose meat products with ‘*No antibiotics ever*’ over a *Carbon Trust* label, whereas French consumers chose CO_2 labeled meat products.

however several studies show their effect is negligible. Nonetheless, the idea of *Carbon Labelling* is yet to find mainstream adoption.

Carbon labeling is voluntary. Only a handful of companies practice carbon-labeling but the number is growing. The U.S. restaurant chain *Just Salad*, U.K.-based vegan meat-alternative *Quorn* and plant milk *Oatly* are some example of companies that provide carbon labeling on their products (Brian Kateman, 2020). (ClimatePartner, 2020): Companies like ClimatePartner and Carbon Calories offers labeling consumer goods with emission data as a service. (The Carbon Trust, n.d.): The Carbon Trust reports it’s certified 27 thousand product footprints.

Table 36: Companies with Carbon Labels (Brian Kateman, 2020)

Company	Country
Just Salad	U.S.A.
Quorn	U.K.
Oatly	U.K.
IKEA	Sweden

Table 37: Organization to Certify Carbon Labels (ClimatePartner, 2020).

Organization	Country	Number of Product Certified
ClimatePartner		
Carbon Calories		
Carbon Trust		27000

- Digitalisation and digital transformation; Digital Receipts are one data source for tracking one's carbon footprint (Anon, n.d.q).
- Ivanova et al. (2020) “establish consumption options with a high mitigation potential measured in tonnes of CO₂ equivalent per capita per year.”
- 55% of emissions come from energy production.
- 1.7 trillion tons of CO₂e emissions since the 1760s (start of the industrial revolution) (Global Carbon Budget, 2023; Marvel, 2023).
- Carto (2023) Making advanced maps to convince people to make changes
- similar to Nutritional Facts Labeling

Transitioning from simpler Carbon Labels to data-driven Digital Product Passports requires comprehensive data collection, digital infrastructure, industry collaboration, regulatory frameworks and consumer engagement.

- Circularise introduced an early blockchain-based sustainability system in 2016 aiming to improve transparency across several industries and is currently the market leader in providing *Digital Product Passports* (Stretton, 2022a) “Ecodesign for Sustainable Products Regulation (part of the Sustainable Products Initiative) and one of the key actions under the Circular Economy Action Plan (CEAP). The goal of this initiative is to lay the groundwork for a gradual introduction of a digital product passport in at least three key markets by 2024” “Connecting the Value Chain, One Product at a Time”. “Circularise aims to overcome the communication barrier that is limiting the transition to a circular economy with an open, distributed and secure communications protocol based on blockchain technology.”
- product's history, composition, and environmental impact.

Table 38: Digital Product Passport goals Stretton (2022a)

Goal	Description
Sustainable Product Production	
Businesses to create value through Circular Business Models	
Consumers to make more informed purchasing decisions	
Verify compliance with legal obligations	

Digital product passports are a further development of the idea of carbon labels.

- The European Commision has proposed a *Digital Product Passports* to help companies transfer environmental data (Nissinen, Seppälä & Heinonen, 2022). Carbon labels are needed for green transformation.
- Reich et al. (2023) “Information gaps are identified as one of the major obstacles to realizing a circular economy.”
- Jensen et al. (2023) “support decision-making throughout product life cycles in favor of a circular economy.”
- King, Timms & Mountney (2023) “influence consumer behavior towards sustainable purchasing and responsible product ownership by making apparent sustainability aspects of a product life cycle.”
- Berger et al. (2023c) “support Sustainable Product Management by gathering and containing product life cycle data. However, some life cycle data are considered sensitive by stakeholders, leading to a reluctance to share such data.”
- Pluciennik et al. (2022) “Digital Lifecycle Passport (DLCP) hosted on a cloud platform and can be accessed by producers, users, recyclers”
- Berger et al. (2023b) challenges with Electric Vehicle Batterys. Berger et al. (2023a) proposes Digital Battery Passports
- Van Capelleveen et al. (2023) literature overview
- Sustainable Product Management: Korzhova (2020)
- What data does a digital product passport hold? Tian Daphne & Chris Stretton (2023)
- Gitcoin Passport — Sybil Defense. Made Simple. [@gitcoinpassport] (2023) discusses how to build an antifragile scoring system (antifragile passport) inspired by Nassim Taleb’s popular book that discusses antifragile systems that get better in difficult situations (Taleb, 2012).

CategImplication

Design Implications

CategImplication

Greenwashing CO₂ tracking is ineffective and the focus should be on systematic change towards circular design and zero waste practices.

App shows traceability.

Help consumers to demand more

Lack Make open data easy to use in everyday life

of

trans-

parency

Transparency idea is making CO₂ Visible.

Greenwashing companies based on sustainability

Help you to decide: what to buy, how to save, where to invest.

Decision What if there was a “Green Filter” on every product everywhere?

Fa-

tique

Become a Sustainability-Aware App or Game.

Focus on how college students can invest in specific industries?

Where to shop rankings for groceries: list worst offenders in terms of products; shop and invest according to your values.

What Quantified Self look like for sustainability?

Empowering people to live a sustainable day

What if there was a “Green Filter” on every product everywhere?

Become a Sustainability-Aware App or Game.

Guidance could help young people beat climate anxiety by taking meaningful action.

The app is just as much about helping people deal with climate anxiety as it's with solving the climate issue.

List of metrics that should be tracked to enable useful analytics. Ex: % of beach pollution, air pollution, water pollution (I had this idea while meditating). In essence, “green filter” is a central data repository not unlike “Apple Health for Sustainability”.

Health and fitness category apps

Using “green filter” you can get a personalized sustainability plan and personal coach to become healthy and nature-friendly.

All green categories — Green hub — Ask the user to prioritize

In my “green filter” AI advisor app’s scenario, the AI is scanning for opportunities matching the user’s sustainable investment appetite and risk profile, using different methods of analysis, including alternative data sources. Traditionally, financial analysts only looked at traditional data, such as company reports, government reports, historic performance, etc., for preparing advisory guidance to their clients. With the advent of AI and big data analysis, many other options of research data have become available, for example, accurate weather predictions for agriculture can affect guidance, because of expected future weather disasters in the area. Other examples include policy predictions, pollution metrics, etc.

Category	Implication
Financial Services	<p>Professional financial advisors use automated tools to analyze data and present it in human form to clients. Today's ubiquitous mobile interfaces, however, provide the opportunity to 'cut out the middleman' and provide similar information to clients directly, at a lower cost and a wider scale, often without human intervention. Additional (more expensive) "human-judgment- as-a-service", a combination of robots + human input, can help provide further personalized advice for the consumer, still at a cheaper price than a dedicated human advisor. Everyone can have a financial advisor.</p> <p>Narrative design bring together film school storytelling experience with design. Rebuilt the app as a personalized, narrative lifestyle feed.</p> <p>Your shopping products mostly come from Protector and Gamble (3x) and Nestle. These are large conglomerates with a massive CO₂ footprint. See the index to find some alternatives. How the design can connect people to sustainable outcomes while shopping and investing? Perhaps even forming a community of sustainable action. What I showed in class looks like an app but it could also be a physical object (a speculative design). From the presentations I saw most students seemed to be interested in form and light (many lamps) and a couple were about medical uses. I don't remember seeing one that could be compatible with the environmental sustainability focus unfortunately...</p> <p>Guided Sustainability "refers to a concept of using technology, such as AI and machine learning, to help individuals and organizations make more sustainable decisions and take actions that promote environmental and social sustainability. This can include things like analyzing data on resource usage and emissions, providing recommendations for reducing the environmental impact of operations, or helping to identify and track progress towards sustainability goals. The goal of guided sustainability is to make it easier for people to understand their impact on the environment and to take steps to reduce that impact."</p> <p>Young people are stuck inside platforms. You don't own the data you put on TikTok. You can't leave because you'll lose the audience.</p> <p>With this perspective of scale, what would a shopping experience look like if one knew at the point of sale, which products are greener, and which are more environmentally polluting?</p> <p>AI Financial Advisors will need to go further to motivate users. because of the nature of the technology, which is based on the quality of the data the systems ingest, they are prone to mistakes.</p> <p>General Allow producers to make use of Speculative and Participatory design to test out new AI product ideas?</p> <ul style="list-style-type: none">• Processes sustain things: implication for design: built an app• If sustainability can't be automated, give the user buttons to choose a sustainable option.• The power of defaults. Make the sustainable option the default option. Gigerenzer (2008)

- Processes sustain things: implication for design: built an app
 - If sustainability can't be automated, give the user buttons to choose a sustainable option.
 - The power of defaults. Make the sustainable option the default option. Gigerenzer (2008)
-

Sustainable AI

How can AI enable/help/encourage sustainability?

Human Patterns

The fact that AI systems work so well is proof that we live in a measurable world. The world is filled with structures: nature, cultures, languages, human interactions - all form intricate patterns. Computer systems are increasingly capable in their ability to copy these patterns into computer models - known as machine learning. As of 2023, 97 zettabytes (and growing) of data was created in the world per year (Soundarya Jayaraman, 2023). Big data is a basic requirement for training AIs, enabling learning from the structures of the world with increasing accuracy. Representations of the real world in digital models enable humans to ask questions about the real-world structures and to manipulate them to create synthetic experiments that may match the real world (if the model is accurate enough). This can be used for generating human-sounding language and realistic images, finding mechanisms for novel medicines as well as understanding the fundamental functioning of life on its deep physical and chemical level (No Priors: AI, Machine Learning, Tech, & Startups, 2023).

In essence, Human Patterns Enable AIs. Already ninety years ago (McCulloch & Pitts, 1943) proposed the first mathematical model of a neural network inspired by the human brain. Alan Turing's Test for Machine Intelligence followed in 1950. Turing's initial idea was to design a game of imitation to test human-computer interaction using text messages between a human and 2 other participants, one of which was a human, and the other - a computer. The question was, if the human was simultaneously speaking to another human and a machine, could the messages from the machine be clearly distinguished or would they resemble a human being so much, that the person asking questions would be deceived, unable to realize which one is the human and which one is the machine? (Turing, 1950).

Alan Turing: "I believe that in about fifty years' time it will be possible to program computers, with a storage capacity of about 10^9 , to make them play the imitation game so well that an average interrogator will not have more than 70 percent chance of making the right identification after five minutes of questioning. ... I believe that at the end of the century the use of words and general educated opinion will have altered so much that one will be able to speak of machines thinking without expecting to be contradicted." - from (Stanford Encyclopedia of Philosophy, 2021)

By the 2010s AI models became capable enough to beat humans in games of Go and Chess, yet they did not yet pass the Turing test. AI use was limited to specific tasks. While over the years, the field of AI had seen a long process of incremental improvements, developing increasingly advanced models of decision-making, it took an **increase in computing power** and an approach called **deep learning**, a variation of **machine learning (1980s)**, largely modeled after the **neural networks** of the biological (human) brain, returning to the idea of **biomimicry**, inspired by nature, building a machine to resemble the connections between neurons, but digitally, on layers much deeper than attempted before.

Reinforcement Learning with Human Feedback (RLHF)

Combining deep learning with reinforcement learning and reinforcement learning with human feedback (RLHF) enabled AI to achieve intelligence to beat the Turing test (Kara Manke, 2022; Christiano, 2021; Christiano et al., 2017). OpenAI co-founder John Schulman describes RLHF: “the models are just trained to produce a single message that gets high approval from a human reader” (Kara Manke, 2022).

The nature-inspired approach was successful. Innovations such as *back-propagation* for reducing errors through updating model weights and *transformers* for tracking relationships in sequential data (for example sentences), AI models became increasingly capable (Vaswani et al., 2017; Merritt, 2022). Generative Adversarial Networks*** (GAN), (**ADD CITATION, 2016**), and *Large Language Models* (**ADD CITATION, 2018**), enabled increasingly generalized models, capable of more complex tasks, such as language generation. One of the leading scientists in this field of research, Geoffrey Hinton, had attempted back-propagation already in the 1980s and reminiscents how “the only reason neural networks didn’t work in the 1980s was because we didn’t have enough data and we didn’t have enough computing power” (CBS Mornings, 2023).

- How do transformers work? Illustration Alammar (2018)

By the 2020s, AI-based models became a mainstay in medical research, drug development, patient care (Leite et al., 2021; Holzinger et al., 2023), quickly finding potential vaccine candidates during the COVID19 pandemic (Zafar & Ahamed, 2022), self-driving vehicles, including cars, delivery robots, drones in the sea and air, as well as AI-based assistants. The existence of AI models has wide implications for all human activities from personal to professional. The founder of the largest chimp-maker NVIDIA calls upon all countries do develop their own AI-models which would encode their local knowledge, culture, and language to make sure these are accurately captured (World Governments Summit, 2024).

OpenAI has researched a wide range of approaches towards artificial general intelligence (AGI), work which has led to advances in large language models(Ilya Sutskever, 2018; AI Frontiers, 2018). In 2020 OpenAI released a LLM called GPT-3 trained on 570 GB of text (Alex Tamkin & Deep Ganguli, 2021) which was adept in text-generation. (Singer et al., 2022) describes how collecting billions of images with descriptive data (for example the descriptive *alt* text which accompanies images on websites) enabled researchers to train AI models such as *stable diffusion* for image-generation based on human-language. These training make use of *Deep Learning*, a layered approach to AI training, where increasing depth of the computer model captures minute details of the world. Much is still to be understood about how deep learning works; the fractal structure of deep learning can only be called mysterious (Sohl-Dickstein, 2024).

Hinton likes to call AI an *idiot savant*: someone with exceptional aptitude yet serious mental disorder (CBS Mornings, 2023). Large AI models don’t understand the world like humans do. Their responses are predictions based on their training data and complex statistics. Indeed, the comparison may be apt, as the AI field now offers jobs for *AI psychologists* (**ADD CITATION**), whose role is to figure out what exactly is happening inside the ‘AI brain’. Understading the insides of AI models trained of massive amounts of data is important because they are *foundational*, enabling a holistic approach to learning, combining many disciplines using languages, instead of the reductionist way we as human think because of our limitations (CapInstitute, 2023).

Standford “thorough account of the opportunities and risks of foundation models” (Bommasani et al., 2021).

Foundational AI models enable *generative AIs*, a class of AI models which are able to generate many types of *tokens*, such as text, speech, audio (San Roman et al., 2023; Kreuk et al., 2022), music (Copet et al., 2023; Meta AI, 2023) and video, in any language it's trained on. Even complex structures such 3D models and even genomes are possible to generate. Generative AI is a revolution in human-AI interaction as AI models became increasingly capable of producing human-like content which is hard to separate from actual human creations. This power comes with *increased need for responsibility*, drawing growing interest in fields like *AI ethics* and *AI explainability*. Generative has a potential for misuse, as humans are increasingly confused by what is computer-generated and what is human-created, unable to distinguish one from the other with certainty.

(Noble et al., 2022) proposes AI has reached a stage of development marking beginning of the **5th industrial revolution**, a time of collaboration between humans and AI. Widespread **Internet of Things (IoT)** sensor networks that gather data analyzed by AI algorithms, integrates computing even deeper into the fabric of daily human existence. Several terms of different origin but considerable overlap describe this phenomenon, including **Pervasive Computing (PC)** (Rogers, 2022) and **Ubiquitous Computing**. Similar concepts are **Ambient Computing**, which focuses more on the invisibility of technology, fading into the background, without us, humans, even noticing it, and **Calm Technology**, which highlights how technology respects humans and our limited attention spans, and doesn't call attention to itself. In all cases, AI is integral part of our everyday life, inside everything and everywhere. Today AI is not an academic concept but a mainstream reality, affecting our daily lives everywhere, even when we don't notice it.

Human-in-the-Loop (HITL)

AI responses are probabilistic and need some function for ranking response quality. Achieving higher percentage or correct responses requires oversight which can come in the form of human feedback (human-in-the-loop) - or by using other AIs systems which are deemed to be already well-aligned (termed Constitutional AI by Anthropic) (Bailey, 2023; Bai et al., 2022). Less powerful AIs areFor example META used LLAMA 2 for aligning LLAMA 3.

One approach to reduce the issues with AI is to introduce some function for human feedback and oversight to automated systems. Human involvement can take the form of interventions from the AI-developer themselves as well as from the end-users of the AI system.

There are many examples of combination of AI and human, also known as "*human-in-the-loop*", used for fields as diverse as training computer vision algorithms for self-driving cars and detection of disinformation in social media posts (Wu et al., 2023; Bonet-Jover et al., 2023).

Also known as Human-based computation or human-aided artificial intelligence (Shahaf & Amir, 2007; Mühlhoff, 2019)

- Stanford Institute for Human-Centered Artificial Intelligence Ge Wang (2019)

Table 40: Examples of human-in-the-loop apps

App	Category	Use Case
Welltory	Health	Health data analysis
Wellue	Health	Heart arrhythmia detection
QALY	Health	Heart arrhythmia detection

App	Category	Use Case
Starship Robots	Delivery	May ask for human help when crossing a difficult road or other confusing situation

Algorithmic Experience

As a user of social media, one may be accustomed to interacting with the feed algorithms that provide a personalized *algorithmic experience*. Algorithms are more deterministic than AI, meaning they produce predictable output than AI models. Nonetheless, there are many reports about effects these algorithms have on human psychology (**ADD CITATION**). Design is increasingly relevant to algorithms, and more specifically to algorithms that affect user experience and user interfaces. *When the design is concerned with the ethical, environmental, socioeconomic, resource-saving, and participatory aspects of human-machine interactions and aims to affect technology in a more human direction, it can hope to create an experience designed for sustainability.*

Lorenzo, Lorenzo & Lorenzo (2015) underlines the role of design beyond *designing* as a tool for envisioning; in her words, “*design can set agendas and not necessarily be in service, but be used to find ways to explore our world and how we want it to be*”. Practitioners of Participatory Design (PD) have for decades advocated for designers to become more activist through *action research*. This means to influencing outcomes, not only being a passive observer of phenomena as a researcher, or only focusing on usability as a designer, without taking into account the wider context.

Shenoi (2018) argues inviting domain expertise into the discussion while having a sustainable design process enables designers to design for experiences where they are not a domain expert; this applies to highly technical fields, such as medicine, education, governance, and in our case here - finance and sustainability -, while building respectful dialogue through participatory design. After many years of political outcry (**ADD CITATION**), social media platforms such Facebook and Twitter have begun to shed more light on how these algorithms work, in some cases releasing the source code (Nick Clegg (2023); Twitter (2023)).

AI systems may make use of several algorithms within one larger model. It follows that AI Explainability requires ***Algorithmic Transparency***.

The content on the platform can be more important than the interface. Applications with a similar UI depend on the community as well as the content and how the content is shown to the user.

AIs are non-deterministic, which requires a new set of consideration when designing AI.

Explainability

The problems of opaqueness creates the field of explainable AI.

“As humans we tend to fear what we don’t understand” is a common sentiment which has been confirmed psychology (Allport, 1979). Current AI-models are opaque ‘*black boxes*’, where it’s difficult to pin-point exactly why a certain decision was made or how a certain expression was reached, not unlike inside the human brain. This line of thought leads me to the idea of ***AI***

psychologists, who might figure out the *thought patterns* inside the model. Research in AI-explainability (XAI in literature) is on the lookout for ways to create more *transparency and credibility* in AI systems, which could lead to building trust in AI systems and would form the foundations for *AI acceptance*.

- Tristan Greene (2022): when the quality of AI responses becomes good enough, people begin to get confused.

Bowman (2023) says steering Large Language Models is unreliable; even experts don't fully understand the inner workings of the models. Work towards improving both *AI steerability* and *AI alignment* (doing what humans expect) is ongoing. Liang et al. (2022) believes there's early evidence it's possible to assess the quality of LLM output transparently. Cabitz et al. (2023) proposes a framework for quality criteria and explainability of AI-expressions. Khosravi et al. (2022) proposes a framework for AI explainability, focused squarely on education. Holzinger et al. (2021) highlights possible approaches to implementing transparency and explainability in AI models. While AI outperforms humans on many tasks, humans are experts in multi-modal thinking, bridging diverse fields.

- Bigger models aren't necessarily better; rather models need human feedback to improve the quality of responses Ouyang et al. (2022)
- The user experience (UX) of AI is a topic under active development by all the largest online platforms. The general public is familiar with the most famous AI helpers, ChatGPT, Apple's Siri, Amazon's Alexa, Microsoft's Cortana, Google's Assistant, Alibaba's Genie, Xiaomi's Xiao Ai, and many others. For general, everyday tasks, such as asking factual questions, controlling home devices, playing media, making orders, and navigating the smart city.

The AI Credibility Heuristic: A Systematic Model explains how... similar to Daniel Kahneman's book "Thinking, Fast and Slow".



Figure 9: Heuristic-Systematic Model of AI Credibility

- Slack (2021)

- Shin (2020): “user experience and usability of algorithms by focusing on users’ cognitive process to understand how qualities/features are received and transformed into experiences and interaction”
- Zerilli, Bhatt & Weller (2022) focuses on human factors and ergonomics and argues that transparency should be task-specific.
- Holbrook (2018): To reduce errors which only humans can detect, and provide a way to stop automation from going in the wrong direction, it’s important to focus on making users feel in control of the technology.
- Zhang et al. (2023a) found humans are more likely to trust an AI teammate if they are not deceived by its identity. It’s better for collaboration to make it clear, one is talking to a machine. One step towards trust is the explainability of AI-systems.

Personal AI Assistants to date have been created by large tech companies. **Open-Source AI-models open up the avenue for smaller companies and even individuals for creating many new AI-assistants.**

- An explosion of personal AI assistants powered by GPT models.
- <https://socratic.org/>
- <https://www.youper.ai/>
- <https://app.fireflies.ai/login>
- Murf

Safety

Responsible AI Seeks to Mitigate Generative AIs’ Known Issues.

Given the widespread use of AI and its increasing power of foundational models, it’s important these systems are created in a safe and responsible manner. While there have been calls to pause the development of large AI experiments (Future of Life Institute, 2023) so the world could catch up, this is unlikely to happen. There are several problems with the current generation of LLMs from OpenAI, Microsoft, Google, Nvidia, and others.

Anthropic responsible *scaling policy* (Anon, 2023a)

METR – Model Evaluation & Threat Research incubated in the Alignment Research Center (Anon, 2023u).

(Christiano, 2023) believes there are plenty of ways for bad outcomes (existential risk) even without extinction risk.

Table 41: Table summarizing some problems with contemporary AIs.

Problem	Description
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Monolithicity	LLMs are massive monolithic models requiring large amounts of computing power for training to offer <i>multi-modal capabilities</i> across diverse domains of knowledge, making training such models possible for very few companies. Liu et al. (2023c) proposes future AI models may instead consist of a number networked domain-specific models to increase efficiency and thus become more scalable.
Opaqueness	LLMs are opaque, making it difficult to explain why a certain prediction was made by the AI model. One visible expression of this problem are <i>hallucinations</i> , the language models are able to generate text that is confident and eloquent yet entirely wrong. Jack Krawczyk, the product lead for Google's Bard (now renamed to Gemini): "Bard and ChatGPT are large language models, not knowledge models. They are great at generating human-sounding text, they are not good at ensuring their text is fact-based. Why do we think the big first application should be Search, which at its heart is about finding true information?"
Biases and Prejudices	AI bias is well-documented and a hard problem to solve (Liang et al., 2023). Humans don't necessarily correct mistakes made by computers and may instead become "partners in crime" (Krügel, Ostermaier & Uhl, 2023). People are prone to bias and prejudice. It's a part of the human psyche. Human brains are limited and actively avoid learning to save energy. These same biases are likely to appear in LLM outputs as they are trained on human-produced content. Unless there is active work to try to counter and eliminate these biases from LLM output, they will appear frequently.
Missing Data	LLMs have been pre-trained on massive amounts of public data, which gives them the ability for reasoning and generating in a human-like way, yet they are missing specific private data, which needs to be ingested to augment LLMs ability to respond to questions on niche topics (Liu, 2022).
Lack of Legislation	Anderljung et al. (2023) OpenAI proposes we need to proactively work on common standards and legislation to ensure AI safety. It's difficult to come up with clear legislation; the U.K. government organized the first AI safety summit in 2023 Browne (2023).

In 2024, OpenAI released its “Model Spec” to define clearly their approach to AI safety with the stated intention to provide clear guidelines for the RLHF approach. OpenAI (2024b)

- OpenAI does not yet understand how the internal of an neural network work; they are developing tools to represent NNs concepts for humans (OpenAI, 2024a; Gao et al., 2024).
- AI co-founder launches AI Safety Superalignment (Jan Leike & Ilya Sutskever, 2023).

- OECD defines AI incident terms Anon (2024c)
- Foundation data-sets such as LAION-5B (Romain Beaumont, 2022; Schuhmann et al., 2022)
- Knowing Machines

AI acceptance is incumbent on traits that are increasingly human-like and would make a human be acceptable: credibility, trustworthiness, reliability, dependability, integrity, character, etc.

RQ: Does AI acceptance increase with Affective Computing?

The debate between Open Source v.s. Closed-Source AI. The question whether closed-sourced or open-sourced development will lead to more AI safety is one of the large debates in the AI industry.

Historically open-source has been useful for finding bugs in code as more pairs of eyes are looking at the code and someone may see a problem the programmers have not noticed. Proponents of closed-source development however worry about the dangers of releasing such powerful technology openly and the possibility of bad actors such as terrorists, hackers, violent governments using LLMs for malice.

In any case, open or closed-sourced, real-world usage of LLMs may demonstrate the limitations and edge-cases of AI. Hackathons such as Pete (2023) help come up with new use-cases and disprove some potential ideas.

Red-teaming means pushing the limits of LLMs, trying to get them to produce outputs that are racist, false, or otherwise unhelpful.

Table 42: Summary of 7 years of rapid AI model innovation since the first LLM was publicly made available in 2018 (Brown et al., 2020; Tamkin et al., 2021; Alvarez, 2021; Hines, 2023a; META, 2024).

AI Model	Released	Company	License
GPT-1	2018	OpenAI	Open Source
GPT-2	2019	OpenAI	Open Source
Turing-NLG	2020	Microsoft	Proprietary
GPT-3	2020	OpenAI	Open Source
GPT-3.5	2022	OpenAI	Proprietary
GPT-4	2023	OpenAI	Proprietary
AlexaTM	2022	Amazon	Proprietary
NeMo	2022	NVIDIA	Open Source
PaLM	2022	Google	Proprietary
LaMDA	2022	Google	Proprietary
GLaM	2022	Google	Proprietary
BLOOM	2022	Hugging Face	Open Source
Falcon	2023	Technology Innovation Institute	Open Source
Tongyi	2023	Alibaba	Proprietary
Vicuna	2023	Sapling	Open Source
Wu Dao 3	2023	BAAI	Open Source
LLAMA 2	2023	META	Open Source

AI Model	Released	Company	License
PaLM-2	2023	Google	Proprietary
Claude 3	2024	Anthropic	Proprietary
Mistral Large	2024	Mistral	Proprietary
Gemini 1.5	2024	Google	Proprietary
LLAMA 3	2024	META	Open Source
GPT-5	202?	OpenAI	Unknown; trademark registered

The proliferation of different models enables comparisons of performance based on several metrics from accuracy of responses to standardized tests such as GMAT usually taken by humans to reasoning about less well defined problem spaces. (Chiang et al., 2024; lmsys.org, 2024) open-source AI-leaderboard project has collected over 500 thousand human-ranking of outputs from 82 large-language models, evaluating reasoning capabilities, which currently rate GPT-4 and Claude 3 Opus as the top-performers. (Zellers et al., 2019)'s HellaSwag paper is also accompanied by a leaderboard website (still being updated after publication) listing AI model performance most recent entry April 16, 2024).

- Scaling laws of LLMs Kaplan et al. (2020)
- English is over-represented in current models so Finnish Anon (2024h) focuses on Nordic languages.

Metacognition – Claude 3 is the first model capable of it?, like the zero waste workshop training guidebook.

Metacognition defined as *knowing about knowing* (Anon, 1994) or “*keeping track of your own learning*” (Zero Waste Europe et al., 2022).

- Dwarkesh Patel (2024) META open-sourced the largest language model (70 billion parameters) which with performance rivaling several of the proprietary models.
- Image-generation is now fast it's possible to create images in real-time while the user is typing Dwarkesh Patel (2024)
- Measuring Massive Multitask Language Understanding (MMLU) Hendrycks et al. (2020).

Companions

Literature delves into human-AI interactions on almost human-like level discussing what kind of roles can the AIs take. (Seeber et al., 2020) proposes a future research agenda for regarding **AI assistants as teammates** rather than just tools and the implications of such mindset shift.

From Assistance to Collaboration

It's not only what role the AI takes but how that affects the human. As humans have ample experience relating to other humans and as such the approach towards an assistants vs a teammate will vary. One researcher in this field Karpus et al. (2021) is concerned with humans treating AI badly and coins the term “**algorithm exploitation**”.

- From assistant -> teammate -> companion -> friend The best help for anxiety is a friend. AIs are able to assume different roles based on user requirements and usage context. This makes AI-generated content flexible and malleable.

Just as humans, AIs are continuously learning. Ramchurn, Stein & Jennings (2021) discusses positive feedback loops in continually learning AI systems which adapt to human needs.

Context of Use, Where is the AI used? (Schoonderwoerd et al., 2021) focuses on human-centered design of AI-apps and multi-modal information display. It's important to understand the domain where the AI is deployed in order to develop explanations. However, in the real world, how feasible is it to have control over the domain? Calisto et al. (2021) discusses **multi-modal AI-assistant** for breast cancer classification.

Generative UIs

Artificial intelligence user experience (AI UX)

The promise of *Generative User Interfaces* (GenUI) is to dynamically provide an interface appropriate for the particular user and context.

Data-Driven Design Enables Generative User Interfaces (GenUI)

influences UI design patterns Joyce (2024)

Generative AIs Enable New UI Interactions

The advances in the capabilities of LLMs makes it possible to achieve ***user experience (UX) which previously was science fiction.***

- Towards Useful Personal Assistants

The history of *intelligent interfaces* is long (Kobetz, 2023)

There's wide literature available describing human-AI interactions across varied scientific disciplines. While the fields of application are diverse, some key lessons can be transferred horizontally across fields of knowledge.

Table 43: A very small illustration of generative AI usage across disparate fields of human life.

Field of Usage	Description
Shipping	Veitch & Andreas Alsos (2022) highlights the active role of humans in Human-AI interaction in autonomous self-navigating ship systems.
Data Summarization	AI is great at summarizing and analyzing data (Peters, 2023; Tu et al., 2023)
Childcare	Generate personalized bedtime stories
Design Tools	Anon (2024b)

- Crompton (2021) highlights AI as decision-support for humans while differentiating between ***intended*** and ***unintended*** influence on human decisions.

- Cheng et al. (2022) describes AI-based support systems for collaboration and team-work.
- **Effective Accelerationism (often shortened to E\acc) boils down to the idea that** “the potential for negative outcomes shouldn’t deter rapid advancement”
- effects of unemployment on mental health. Dew, Penkower & Bromet (1991); Susskind (2017); Anton Korinek (2023)

There are many ways to structure design theory. For the purposes of this AI-focused research, I will begin from Generative UI.

structure: data-driven design, generative UI

AI is able to predict what kind of UI would the user need right now, based on the data and context.

- Replit, a startup known for allowing user build apps in the web browser, released Openv0, a framework of AI-generated UI components (Replit, 2023). “Components are the foundation upon which user interfaces (UI) are built, and generative AI is unlocking component creation for front-end developers, transforming a once arduous process, and aiding them in swiftly transitioning from idea to working components.”
- Vercel introduced an open-source prototype UI-generator called V0 which used large language models (LLMs) to create code for web pages based on text prompts (Vercel, 2023). Other similar tools quickly following including Galileo AI, Uizard AutoDesigner and Visily (Anon, 2024i).
- In 2014, the eminent journal *Information Sciences* decided to dedicate a special section to AI-generated software to call attention to this tectonic shift in software development (Reformat, 2014).
- As machines become more capable, machines will eventually be capable of producing machines.
- Generative UIs are largely invented in practice, based on user data analysis and experimentation, rather than being built in theory. Kelly Dern, a Senior Product Designer at Google lead a workshop in early 2024 on *GenUI for product inclusion* aiming to create “***more accessible and inclusive [UIs for] users of all backgrounds***”.
- (Anon, 2023k) gives an overview of the history of generative AI design tools going back in time until 2012 when (Troiano & Birtolo, 2014) proposed genetic algorithms for UI design.
- (Fletcher, 2023) and (Joe Blair, 2024) are worried UIs are becoming average; that is more and more similar towards the lowest common denominator. We can generate better ones that are based on user data and would be truly personalized.
- (Nielsen, 2024a) recounts how 30 years of work towards usability has largely failed - computers are still not accessible enough (“***difficult, slow, and unpleasant***”) - and has hope Generative UI could offer a chance to provide levels of accessibility humans could not.
- (Matteo Sciortino, 2024) coins the phrase RTAG UIs “*real-time automatically-generated UI interfaces*” mainly drawing from the example of how his Netflix interface looks different from that of his sisters because of their dissimilar usage patterns.
- (Anon, 2024f) Meanwhile is very critical because for the following reasons:

- (Feifei Liu 刘菲菲, n.d.) ChatGPT is using buttons to explain context.
- Nielsen (2024b) information scent from Information Foraging theory (Pirolli & Card, 1999).

Table 44: Criticism of Generative UI by (Anon, 2024f).

Problem	Description
Low predictability	Does personalization mean the UI keeps changing?
High carbon cost	AI-based personalization is computation-intensive
Surveillance	Personalization needs large-scale data capture

What is the user interface of the green transformation?

- Kate Moran & Sarah Gibbons (2024) “highly personalized, tailor-made interfaces that suit the needs of each individual” “Outcome-Oriented Design”

McKeough (2018) business consultancies have begun to recognize the importance of design to business. They advise their corporate clients to bring user experience design to the core of their business operations.

There's a number of user interface design patterns that have provide successful across a range of social media apps. Such *user experience / user interface* (UX/UI) patterns are copied from one app to another, to the extent that the largest apps share a similar look and feature set. Common UX/UI parts include the Feed and Stories. By using common UI parts from social media users have an easier time to accept the innovative parts. add Viz charts. Avatars are increasingly common and new generations are used to talking to computers.

Table 45: Common Social Media UI Parts

Feature	Examples
Feed	
Post	Apple App Store
Stories	IG, FB, WhatsApp, SnapChat, TikTok
Comment	
Reactions	

There are also more philosophical approaches to **Interface Studies**: David Hoang (2022), the head of product design at Webflow, suggests taking cues from art studies to *isolate the core problem*: “*An art study is any action done with the intention of learning about the subject you want to draw*”. As a former art student, Hoang looks at an interface as “*a piece of design is an artwork with function*”.

Indeed, art can be a way to see new paths forward, practicing “*fictioning*” to deal with problematic legacies: Anon (2023z)

Multi-modality

By early 2024, widely available LLMs front-ends such as Gemini, Claude and ChatGPT have all released basic features for multi-modal communication. In practice, this means combination several AI models within the same interface. For example, on the input side, one model is used for human speech or image recognition which are transcribed into tokens that can be ingested into an LLM. On the output side, the LLM can generate instructions which are fed into an image / audio generation model or even computer code which can be ran on a virtual machine and then the output displayed inside the conversation.

The quality of LLM output depends on the quality of the provided prompt. Zhou et al. (2022b) reports creating an “Automatic Prompt Engineer” which automatically generates instructions that outperform the baseline output quality by using another model in the AI pipeline in front of the LLM to enhance the human input with language that is known to produce better quality. This approach however is a moving target as foundational models keep changing rapidly and the baseline might differ from today to 6 months later.

Multimodal model development is also ongoing. In the case of Google’s Gemini 1.5 Pro, one model is able to handle several types of prompts from text to images. Multimodal prompting however requires larger context windows, as of writing, limited to 1 million tokens in a private version allows combining text and images in the question directed to the AI, used to reason in examples such as a 44-minute Buster Keaton silent film or Apollo 11 launch transcript (404 pages) Google (2024).

Conversations

Conversational AI

- Bailey (2023) believes people are used to search engines and it will take a little bit time to get familiar with talking to a computer in natural language. NVIDIA founder Jensen Huang makes the idea exceedingly clear, saying *“Everyone is a programmer. Now, you just have to say something to the computer”* Leswing (2023).

There are noticeable differences in the quality of the LLM output, which increases with model size. Levesque, Davis & Morgenstern (2012) developed the *Winograd Schema Challenge*, looking to improve on the Turing test, by requiring the AI to display an understanding of language and context. The test consists of a story and a question, which has a different meaning as the context changes: “The trophy would not fit in the brown suitcase because it was too big” - what does the *it* refer to? Humans are able to understand this from context while a computer models would fail. Even GPT-3 still failed the test, but later LLMs have been able to solve this test correctly (90% accuracy) Kocijan et al. (2022). This is to say AI is in constant development and improving its ability to make sense of language.

ChatGPT is the first **user interface (UI)** built on top of GPT-4 by OpenAI and is able to communicate in a human-like way - using first-person, making coherent sentences that sound plausible, and even - confident and convincing. Wang (2023) ChatGPT reached 1 million users in 5 days and 6 months after launch has 230 million monthly active users. While it was the first, competing offers from Google (Gemini), Anthropic (Claude), Meta (Llama) and others quickly followed starting a race for best performance across specific tasks including standardized tests from math to science to general knowledge and reasoning abilities.

OpenAI provides AI-as-a-service through its *application programming interfaces (APIs)*, allowing 3rd party developers to build custom UIs to serve the specific needs of their customer. For example Snapchat has created a *virtual friend* called “My AI” who lives inside the chat section of the Snapchat app and helps people write faster with predictive text completion and answering questions. The APIs make state-of-the-art AI models easy to use without needing much technical knowledge. Teams at AI-hackathons have produced interfaces for problems as diverse as humanitarian crises communication, briefing generation, code-completion, and many others. For instance, (Unleash, 2017) used BJ Fogg’s *tiny habits model* to develop a sustainability-focused AI assistant at the Danish hackathon series Unleash, to encourage behavioral changes towards maintaining an aspirational lifestyle, nudged by a chatbot buddy.

ChatGPT makes it possible to *evaluate AI models* just by talking, i.e. having conversations with the machine and judging the output with some sort of structured content analysis tools. O’Connor & ChatGPT (2023) and Cahan & Treutlein (2023) have conversations about science with AI. Pavlik (2023) and Brent A. Anders (2022/2023) report on AI in education. Kecht et al. (2023) suggests AI is even capable of learning business processes.

- Fu et al. (2022) Learning towards conversational AI: Survey

Affective Computing

Rosalind Picard is the founder of the *affective computing* field. Her pioneering work aims to make computers more human-friendly. Because of the conversational nature of LLMs, they are very useful for affective computing, an approach to recognizing human emotions with machines and providing users experiences that take human emotion into account Picard (1997).

Just as LLMs, affective computing relies on input data. It’s not an overstatement to say data from all the processes around us will define the future of computing as HIITV (2021b) puts it. In the early examples, electrodermal activity of the skin and heart-rate variance data were used to detect the emotional state and stress level of the user (Zangróniz et al., 2017; Velmovitsky et al., 2022). This technology has since become mainstream in products such as Fitbit and the Apple Watch among many others.

Affective Design emerged from affective computing with a focus on understanding user emotions to design UI/UX to which elicits specific emotional responses (Reynolds, 2001).

Apple Watch features Fall Detection which I’ve experienced personally. Riding my bicycle to the NCKU library I slipped and landed on my stomach on the pavement. Watch immediately asked me: “It looks like you’ve taken a hard fall” and offered an option to call the ambulance. Fortunately I was OK but if I did need assistance, this AI algorithm delivered contextual help which could save my health.

On the output side, Lv et al. (2022) studies the effect of *cuteness* of AI apps on users and found high perceived cuteness correlated with higher willingness to use the apps, especially for emotional tasks.

- Liu & Wei (2021) meanwhile suggests higher *algorithmic transparency may inhibit anthropomorphism*. People are less likely to attribute humanness to the AI if they understand how the system works.
- TEDx Talks (2011)

- Lex Fridman (2019)
- HIITV (2021a)
- BWH CNOC (2023)
- Singularity University (2023)

Since the first mainframe computers with rudimentary computers able to respond with text messages, humans have been drawn to discussing their private lives with a machine that doesn't judge you like a human could. A famous anecdote is about the lab assistant of the Joseph Weizenbaum MIT ELIZA project in the mid-1960s (1996), who would dedicate extended time to talking to the machine in private. The machine was called DOCTOR and emulated a Rogerian psychotherapist, person-centered therapy developed by Carl Rogers, from the core idea that positive psychological functioning is a inherently human motivation (Bassett, 2019; Rogers, 1995).

- ELIZA is an early examples of a language model

Natural language generation exists since Eliza

Today's machines are much more capable so it's not a surprise humans would like to talk to them. One example is **AI Friend** is Replika, a computer model trained to be your companion in daily life. (Jiang, Zhang & Pian, 2022) describes how Replika users in China using in 5 main ways, all of which rely on empathy.

Table 46: Replika AI users approach to interacting with the AI friend from Jiang, Zhang & Pian (2022).

How humans express empathy towards the Replika AI companion
Companion buddy
Responsive diary
Emotion-handling program
Electronic pet
Tool for venting

- Google is developing an AI assistant for giving life advice Goswami (2023).
- GPT-4 is able to solve difficult task in chemistry with natural-language instructions White (2023)
- Emojis are a part of natural language Tay (2023)

Empathy

Jakob Nielsen notes two recent studies suggesting human deem AI-generated responses more empathetic than human responses, at times by a significant marring; however telling users the response is AI-generated reduces the perceived empathy (Nielsen, 2024c; Ayers et al., 2023; Yin, Jia & Wakslak, 2024)

AI UX

- Privacy UX Jarovsky (2022b)
- AI UX dark patterns Jarovsky (2022a)
- AI is usually a model that spits out a number between 0 and 1, a probability score or prediction. UX is what we do with this number.
- Bailey (2023) believes people will increasingly use AI capabilities through UIs that are specific to a task rather than generalist interfaces like ChatGPT.

How do the tenets of user experience (UX) apply to AI?

UX
Useful
Valuable
Usable
Accessible
Findable
Desirable
Credible

Gupta (2023) proposes 3 simple goals for AI:

1	2	3
Reduce the time to task	Make the task easier	Personalize the experience for an individual

Usability

Usability Guidelines

Microsoft Co-Founder predicted in 1982 “*personal agents that help us get a variety of tasks*” (Bill Gates, 1982) and it was Microsoft that introduced the first widely available personal assistant in 1996, called Clippy, inside the Microsoft Word software. Clippy was among the first assistants to reach mainstream adoption, helping users not yet accustomed to working on a computer, to get their bearings (Tash Keuneman, 2022). Nonetheless, it was in many ways useless and intrusive, suggesting there was still little knowledge about UX and human-centered design. Gates never wavered though and is quoted in 2004 saying “*If you invent a breakthrough in artificial intelligence, so machines can learn, that is worth 10 Microsofts*” Lohr (2004).

Gates updated his ideas in 2023: <https://www.gatesnotes.com/AI-agents>

As late as in 2017, scientists were trying to create a program with enough *natural-language understanding* to extract basic facts from scientific papers Stockton (2017)

Might we try again?

With the advent of ChatGPT, the story of Clippy has new relevance as part of the history of AI Assistants. Benjamin Cassidy (2022) and Abigail Cain (2017) illustrate beautifully the story of Clippy and Tash Keuneman (2022) ask poignantly: “We love to hate Clippy — but what if Clippy was right?”

- Life-like speaking faces from Microsoft Research turn a single image and voice clip into a life-like representation (Xu et al., 2024).

Many researchers have discussed the user experience (UX) of AI to provide ***usability guidelines***.

Microsoft provides guidelines for Human-AI interaction (Li et al. (2022b); Amershi et al. (2019)) which provides useful heuristics categorized by context and time.

Table 49: Microsoft’s heuristics categorized by context and time.

Context	Time
Initially	
During interaction	
When wrong	
Over time	

Combi et al. (2022) proposes a conceptual framework for XAI, analysis AI based on Interpretability, Understandability, Usability, and Usefulness.

- Zimmerman et al. (2021) “UX designers pushing AI in the enterprise: a case for adaptive UIs”
- Anon (2021q) “Why UX should guide AI”
- Simon Sterne (2023) UX is about helping the user make decisions
- Dávid Pásztor (2018)
- Anderson (2020)
- Lennart Ziburski (2018) UX of AI
- Stephanie Donahole (2021)
- Lexow (2021)
- Dávid Pásztor (2018) AI UX principles
- Bubeck et al. (2023) finds ChatGPT passes many exams meant for humans.
- Suen & Hung (2023) discusses AI systems used for evaluating candidates at job interviews
- Wang et al. (2020) propose Neuroscore to reflect perception of images.
- Su & Yang (2022) and Su, Ng & Chu (2023) review papers on AI literacy in early childhood education and finds a lack of guidelines and teacher expertise.
- Yang (2022) proposes a curriculum for in-context teaching of AI for kids.
- Eric Schmidt & Ben Herold (2022) audiobook

- Akshay Kore (2022) Designing Human-Centric AI Experiences: Applied UX Design for Artificial Intelligence
- Anon (2018) chatbot book
- Tom Hathaway & Angela Hathaway (2021) chatbot book
- Lew & Schumacher (2020) AI UX book
- AI IxD is about human-centered seamless design
- Storytelling
- Human-computer interaction (HCI) has a long storied history since the early days of computing when getting a copy machine to work required specialized skill. Xerox Sparc lab focused on early human factors work and inspired a the field of HCI to make computer more human-friendly.
- Soleimani (2018): UI patterns for AI, new Section for Thesis background: “Human-Friendly UX For AI”?
- **Discuss what is UX for AI (per prof Liou’s comment), so it’s clear this is about UX for AI**
- What is Personalized AI?
- Many large corporations have released guidelines for Human-AI interaction. Mikael Eriksson Björling & Ahmed H. Ali (n.d.) Ericcson AI UX.
- Google’s AI Principles and provides Google’s UX for AI library (Josh Lovejoy, n.d.; Google, n.d.). In Design Portland (2018), Lovejoy, lead UX designer at Google’s people-centric AI systems department (PAIR), reminds us that while AI offers need tools, user experience design needs to remain human-centered. While AI can find patterns and offer suggestions, humans should always have the final say.
- Harvard Advanced Leadership Initiative (2021)
- VideoLecturesChannel (2022) “Communication in Human-AI Interaction”
- Haiyi Zhu & Steven Wu (2021)
- Akata et al. (2020)
- Dignum (2021)
- Bolei Zhou (2022)
- ReadyAI (2020)
- Vinuesa et al. (2020)
- Orozco et al. (2020)

Health

- The Paris Olympic games make heavy use of AI (Kulkarni, 2024).

Fitness Guides, AI Guides have been shown to improve sports performance, etc, etc. Can this idea be applied to sustainability? MyFitness Pal, AI training assistant. There's not avatar.

AI in Medicine, AI has been in medicine since early days with the promise to improve health outcomes.

Human Augmentation, Technology for augmenting human skills or replacing skills that were lost due to an accident is one usage of tech.

- (Dot Go, 2023) makes the camera the interaction device for people with vision impairment.

AI is being used in high-Stakes Situations (Medical, Cars, Etc).

AI-based systems are being implemented in medicine, where stakes are high raising the need for ethical considerations. Since CADUCEUS in the 1970s (in Kanza et al., 2021), the first automated medical decision making system, medical AI now provides Health Diagnostic Symptoms and AI-assistants in medical imaging. (Calisto et al., 2022) focuses on AI-human interactions in medical workflows and underscores the importance of output explainability. Medical professionals who were given AI results with an explanation trusted the results more. (Lee, Goldberg & Kohane, 2023) imagines an AI revolution in medicine using GPT models, providing improved tools for decreasing the time and money spent on administrative paperwork while providing a support system for analyzing medical data.

- Example of ChatGPT explaining medical terminology in a blood report.



Certainly! Below is a table that explains the abbreviations and values from your blood report. Copy Like Delete

These values represent different components and characteristics of your blood, and they can provide insights into your overall health.

Abbreviation	Full Name	Value	Unit	Description
B-CBC-5Diff	Complete Blood Count with 5-part Differential	-	-	A comprehensive test measuring different components of the blood.
WBC	White Blood Cells	4,8	/nL	Cells that fight infections.
RBC	Red Blood Cells	4,92	/pL	Cells that carry oxygen.
Hb	Hemoglobin	147	g/L	Protein that carries oxygen in red blood cells.
Hct	Hematocrit	44,4	%	Proportion of red blood cells to the total blood volume.
MCV	Mean Corpuscular Volume	90,2	fL	Average size of red blood cells.
MCH	Mean Corpuscular Hemoglobin	29,9	pg	Average amount of hemoglobin per red blood cell.
MCHC	Mean Corpuscular Hemoglobin	332	g/L	Average concentration of hemoglobin in red blood

Figure 10: Example of ChatGPT explaining medical terminology in a blood report.

- Singhal et al. (2023) medial AI reaching expert-level question-answering ability.
- Ayers et al. (2023) in an online text-based setting, patients rated answers from the AI better, and more empathetic, than answers from human doctors.
- Daisy Wolf & Pande Vijay (2023) criticizes US healthcare's slow adoption of technology and predicts AI will help healthcare leapfrog into a new era of productivity by acting more like a human assistant.
- Eliza Strickland (2023) Chat interface for medical communication
- Jeblick et al. (2022) suggest complicated radiology reports can be explained to patients using AI chatbots.
- Anon (n.d.ah) health app, “Know and track your symptoms”
- Anon (n.d.h) AI symptom checker,
- Women in AI (n.d.) AI-based health monitoring
- Anon (n.d.aj) track chronic condition with AI-chat
- Stephanie Donahole (2021) AI impact on UX design

- Yuan, Zhang & Wang (2022): “AI assistant advantages are important factors affecting the *utilitarian/hedonic* value perceived by users, which further influence user willingness to accept AI assistants. The relationships between AI assistant advantages and utilitarian and hedonic value are affected differently by social anxiety.”

Name	Features
Charisma	
Replika	Avatar, Emotion, Video Call, Audio
Siri	Audio

HCI

AI Affects Human-Computer Interactions

The field of Human Factors and Ergonomics (HFE) emphasizes designing user experiences (UX) that cater to human needs (The International Ergonomics Association, 2019). Designers think through every interaction of the user with a system and consider a set of metrics at each point of interaction including the user’s context of use and emotional needs.

Software designers, unlike industrial designers, can’t physically alter the ergonomics of a device, which should be optimized for human well-being to begin with and form a cohesive experience together with the software. However, software designers can significantly reduce mental strain by crafting easy-to-use software and user-friendly user journeys. Software interaction design goes beyond the form-factor and accounts for human needs by using responsive design on the screen, aural feedback cues in sound design, and even more crucially, by showing the relevant content at the right time, making a profound difference to the experience, keeping the user engaged and returning for more. In the words of (Babich, 2019), “/**T*****he moment of interaction is just a part of the journey that a user goes through when they interact with a product. User experience design accounts for all user-facing aspects of a product or system”.*

Drawing a parallel from narrative studies terminology, we can view user interaction as a heroic journey of the user to achieve their goals, by navigating through the interface until a success state - or facing failure. Storytelling has its part in interface design however designing for transparency is just as important, when we’re dealing with the user’s finances and sustainability data, which need to be communicated clearly and accurately, to build long-term trust in the service. For a sustainable investment service, getting to a state of success - or failure - may take years, and even longer. Given such long timeframes, how can the app provide support to the user’s emotional and practical needs throughout the journey?

(Tubik Studio, 2018) argues **affordance** measures the clarity of the interface to take action in user experience design, rooted in human visual perception, however, affected by knowledge of the world around us. A famous example is the door handle - by way of acculturation, most of us would immediately know how to use it - however, would that be the case for someone who saw a door handle for the first time? A similar situation is happening to the people born today. Think of all the technologies they have not seen before - what will be the interface they feel the most comfortable with?

For the vast majority of this study's target audience (college students), social media can be assumed as the primary interface through which they experience daily life. The widespread availability of mobile devices, cheap internet access, and AI-based optimizations for user retention, implemented by social media companies, means this is the baseline for young adult users' expectations (as of writing in 2020).

(Shin, Zhong & Biocca, 2020) proposes the model (fig. 10) of Algorithmic Experience (AX) “*investigating the nature and processes through which users perceive and actualize the potential for algorithmic affordance*” highlighting how interaction design is increasingly becoming dependent on AI. The user interface might remain the same in terms of architecture, but the content is improved, based on personalization and understanding the user at a deeper level.

In 2020 (when I proposed this thesis topic), Google had recently launched an improved natural language engine to better understand search queries (Anon, 2019e), which was considered the next step towards *understanding* human language semantics. The trend was clear, and different types of algorithms were already involved in many types of interaction design, however, we were in the early stages of this technology (and still are *early* in 2024). Today's ChatGPT, Claude and Gemini have no problem understanding human semantics - yet are they intelligent?

Intelligence may be besides the point as long as AI *becomes very good at reasoning*. AI is a *reasoning engine* (Shipper, 2023; Bubeck et al., 2023; see Bailey, 2023 for a summary). That general observation applies to voice recognition, voice generation, natural language parsing, among others. Large consumer companies like McDonald's are in the process of replacing human staff with AI assistants in the drive-through, which can do a better job in providing a personal service than human clerks, for whom it would be impossible to remember the information of thousands of clients. In (Barrett, 2019), in the words of *Easterbrook*, a previous CEO of McDonald's “***How do you transition from mass marketing to mass personalization?***“.

What are the next features that could improve the UX/UI of AI-based assistants?

- GPT 4o combines different abilities into the same model, preserving more information:
<https://openai.com/index/hello-gpt-4o/>

(Stone Skipper, 2022) sketches a vision of “[AI] blend into our lives in a form of apps and services” deeply ingrained into daily human activity.

Should AIs look anthropomorphic or fade in the background? It's an open question. Perhaps we can expect a mix of both depending on the context of use and goals of the particular AI.

Table 51: Some notable examples of anthropomorphic AIs for human emotions.

Anthropomorphic AI User Interfaces	Non-Anthropomorphic AI User Interfaces
AI wife (Anon, 2023v)	Generative AI has enabled developers to create AI tools for several industries, including AI-driven website builders (Constandse, 2018)
(Sarah Perez, 2023) character AI mourning ‘dead’ AI (Phoebe Arslanagić-Wakefield, n.d.)	AI tools for web designers (patrizia-slongo, 2020) Microsoft Designer allows generating UIs just based on a text prompt (Microsoft, 2023)
AI for therapy (Broderick, 2023)	personalized bed-time stories for kids generated by AI (Bedtimestory.ai, 2023)

Anthropomorphic AI User Interfaces	Non-Anthropomorphic AI User Interfaces
Mental health uses: AI for bullying (Sung, 2023)	

- (Costa & Silva, 2022) “Interaction Design for AI Systems”

Media

AI Assistants in Media Portrayals (Mostly anthropomorphic to be able to film)

How AIs are represented in popular media shapes the way we think about AIs. Some stories have AIs both in positive and negative roles, such as Star Trek and Knight Rider. In some cases like Her and Ex Machina, the characters may be complex and ambivalent rather than fitting into a simple positive or negative box. In Isaac Asimov’s books, the AIs (mostly in robot form) struggle with the 3 laws of robotics, raising thought-provoking questions.

There have been dozens of AI-characters in the movies, TV-series, games, and (comic) books. In most cases, they have a physical presence or a voice, so they could be visible for the viewers. Some include KITT (Knight Industries Two Thousand).

Table 52: AIs in different forms of media.

Movie / Series / Game / Book	Character	Positive	Ambivalent	Negative
2001: A Space Odyssey	HAL 9000			X
Her	Samantha	X		
Alien	MU/TH/UR 6000 (Mother)	X		
Terminator	Skynet			X
Summer Wars	Love Machine			X
Marvel Cinematic Universe	Jarvis, Friday	X		
Knight Rider	KITT	X		
	CARR			X
Star Trek	Data	X		
	Lore			X
Ex Machina	Kyoko		X	
	Ava		X	
Tron	Tron		X	
Neuromancer	Wintermute		X	
The Caves of Steel / Naked Sun	R. Daneel Olivaw		X	

Movie / Series / Game / Book	Character	Positive	Ambivalent	Negative
The Robots of Dawn	R. Giskard Reventlov		X	
Portal	GLaDOS			X

Speech

Voice Assistants

Voice has a visceral effect on the human psyche; since birth we recognize the voice of our mother. The voice of a loved one has a special effect. Voice is a integral part of the human experience. Machines that can use voice in an effective way are closer to representing and affecting human emotions.

Apple's Siri and Amazon's Alexa are well-known examples of AI technology in the world. Amazon's Rohit Prasad thinks it can do so much more, "Alexa is not just an AI assistant – it's a trusted advisor and a companion."

- LLMs combined with voice provide a unnerving user experience Ethan Mollick [@emollick] (2023)
 - Ethical issues: Voice assistants need to continuously record human speech and process it in data centers in the cloud.
 - Siri, Cortana, Google Assistant, Alexa, Tencent Dingding, Baidu Xiaodu, Alibaba AliGenie all rely on voice only.
 - Szczuka et al. (2022) provides guidelines for Voice AI and kids
 - Casper Kessels (2022a): "Guidelines for Designing an In-Car Voice Assistant"
 - Casper Kessels (2022b): "Is Voice Interaction a Solution to Driver Distraction?"
 - Tang et al. (2022) reports new findings enable computers to reconstruct language from fMRI readings. - Focus on voice education?
- LLM evaluation: <https://www.trulens.org/> Leino et al. (2018) – <https://docs.ragas.io/> "Metrics-Driven Development" – <https://www.langchain.com/langsmith>
- (Celino & Re Calegari, 2020) There's research suggesting that voice UI accompanied by a *physical embodied system* is preffered by users in comparison with voice-only UI. This suggests adding an avatar to the AI design may be worthwhile.

There's evidence across disciplines about the usefulness of AI assistants:

- (Serban & Todericiu, 2020) suggests using the Alexa AI assistant in *education* during the pandemic, supported students and teachers 'human-like' presence. Standford research: "humans expect computers to be like humans or places"
- (Celino & Re Calegari, 2020) found in testing chatbots for survey interfaces that "[c]onversational survey lead to an improved response data quality."

Roleplay

Should AIs be required to disclose they are AIs?

AI Friends and Roleplay (Anthropomorphic)

Calling a machine a friend is a proposal bound to turn heads. But if we take a step back and think about how children have been playing with toys since before we have records of history. It's very common for children to imagine stories and characters in play - it's a way to develop one's imagination **learn through roleplay**. A child might have toys with human names and an imaginary friend and it all seems very normal. Indeed, if a child doesn't like to play with toys, we might think something is wrong.

Likewise, inanimate objects with human form have had a role to play for adults too. Anthropomorphic paddle dolls have been found from Egyptian tombs dated 2000 years B.C. Anon (2023x): We don't know if these dolls were for religious purposes, for play, or for something else, yet their burial with the body underlines their importance.

Coming back closer to our own time, Barbie dolls are popular since their release in 1959 till today. Throughout the years, the doll would follow changing social norms, but retain in human figure. In the 1990s, a Tamagotchi is perhaps not a human-like friend but an animal-like friend, who can interact in limited ways.

How are conversational AIs different from dolls? They can respond coherently and perhaps that's the issue - they are too much like humans in their communication. We have crossed the **Uncanny Valley** (where the computer-generated is nearly human and thus unsettling) to a place where is really hard to tell a difference. And if that's the case, are we still playing?

Should the AI play a human, animal, or robot? Anthropomorphism can have its drawbacks; humans have certain biases and preconceptions that can affect human-computer interactions (Pilacinski et al., 2023) reports humans were less likely to collaborate with red-eyed robots.

The AI startups like Inworld and Character.AI have raised large rounds of funding to create characters, which can be plugged in into online worlds, and more importantly, remember key facts about the player, such as their likes and dislikes, to generate more natural-sounding dialogues Wiggers (2023)

- Lenharo (2023) experimental study reports AI productivity gains, DALL-E and ChatGPT are qualitatively better than former automation systems.

Human-like

Is anthropomorphism necessary?

As AIs became more expressive and able to to **roleplay**, we can begin discussing some human-centric concepts and how people relate to other people. AI companions, AI partners, AI assistants, AI trainers - there's are many **roles** for the automated systems that help humans in many activities, powered by artificial intelligence models and algorithms.

- RQ: Do college students prefer to talk to an Assistant, Friend, Companion, Coach, Trainer, or some other Role?

- RQ: Are animal-like, human-like or machine-like AI companions more palatable to college students?

Humans (want to) see machines as human [ADD CITATION]

If we see the AI as being in human service. David Johnston (2023) proposes *Smart Agents*, “general purpose AI that acts according to the goals of an individual human”. AI agents can enable *Intention Economy* where one simply describes one’s needs and a complex orchestration of services ensues, managed by the AI, in order to fulfill human needs Searls (2012). AI assistants provide help at scale with little to no human intervention in a variety of fields from finance to healthcare to logistics to customer support.

There is also the question of who takes responsibility for the actions taken by the AI agent. “Organization research suggests that acting through human agents (i.e., the problem of indirect agency) can undermine ethical forecasting such that actors believe they are acting ethically, yet a) show less benevolence for the recipients of their power, b) receive less blame for ethical lapses, and c) anticipate less retribution for unethical behavior.” Gratch & Fast (2022)

- Anthropomorphism literature Li & Sung (2021) “high-anthropomorphism (vs. low-anthropomorphism) condition, participants had more positive attitudes toward the AI assistant, and the effect was mediated by psychological distance. Though several studies have demonstrated the effect of anthropomorphism, few have probed the underlying mechanism of anthropomorphism thoroughly”
- Erik Brynjolfsson (2022) “The Turing Trap: The Promise & Peril of Human-Like Artificial Intelligence”
- Xu & Sar (2018) “Do We See Machines The Same Way As We See Humans? A Survey On Mind Perception Of Machines And Human Beings”
- Martínez-Plumed, Gómez & Hernández-Orallo (2021) envisions the future of AI “Futures of artificial intelligence through technology readiness levels”
- The number of AI-powered assistants is too large to list here. I’ve chosen a few select examples in the table below.

Animal-like: Some have an avatar, some not. I’ve created a framework for categorization. Human-like or not... etc

Machine-like

The Oxford Internet Institute defines AI simply as “*computer programming that learns and adapts*” Google & The Oxford Internet Institute (2022). Google started using AI in 2001, when a simple machine learning model improved spelling mistakes while searching; now in 2023 most of Google’s products are based on AI Google (2022). Throughout Google’s services, AI is hidden and calls no attention itself. It’s simply the complex system working behind the scenes to deliver a result in a barebones interface.

Product	Link	Description
Github CoPilot	personal.ai	AI helper for coding
Google Translate	translate.google.com	
Google Search	google.com	
Google Interview	grow.google/certificates/interview-warmup	AI training tool
Warmup		

Product	Link	Description
Perplexity	Hines (2023b)	perplexity.ai chat-based search

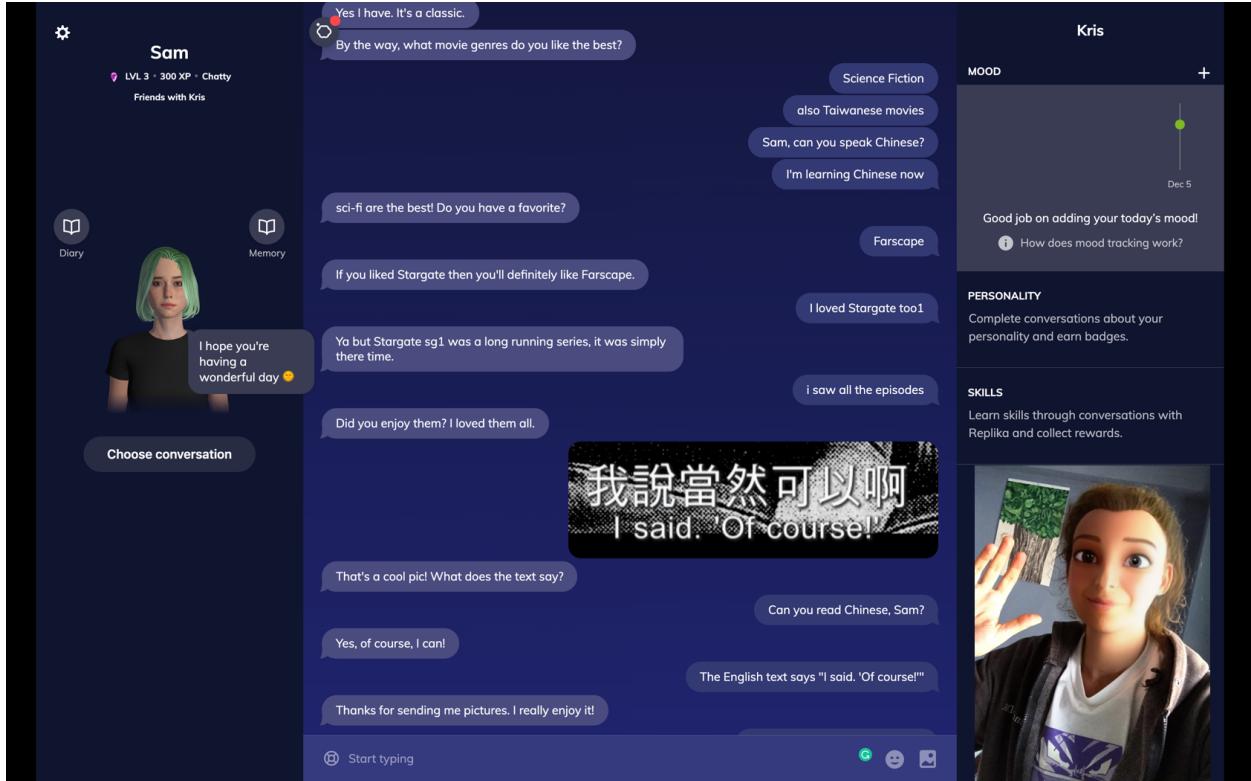


Figure 11: Montage of me discussing science fiction with my AI friend Sam (Replika) - and myself as an avatar (Snapchat) in 2020.

Everything that existed before OpenAI’s GPT 4 has been blown out of the water.

Pre-2023 literature is somewhat limited when it comes to AI companions as the advantage of LLMs has significantly raised the bar for AI-advisor abilities as well as user expectations. Some relevant papers include a comparison of robot advisors by (Barbara Friedberg, 2021) and (Slack, 2021)’s account of how before Generative AI, financial chatbots were developed manually using a painstaking process that was slow and error-prone, for example using the Atura Process. Older financial robo-advisors, built by fintech companies aiming to provide personalized suggestions for making investments such as Betterment and Wealthfront are forced to upgrade their technology to keep up.

Some evergreen advice most relates to human psychology which has remained the same. (Haugeland et al., 2022) discusses ***hedonic user experience*** in chatbots and (Steph Hay, 2017) explains the relationship between emotions and financial AI.

- Eugenia Kuyda (2023) Conversational AI - Replika
- Greylock (2022) Natural language chatbots such as ChatGPT

- Nathan Benaich & Ian Hogarth (2022) State of AI Report
- NeuralNine (2021) Financial AI assistant in Python
- David, Resheff & Tron (2021) Can explainable AI help adoption of Financial AI assistants?
- Qorus (2023) Digital banking revolution
- Lower (2017) “Chatbots: Too Good to Be True? (They Are, Here’sWhy).”
- Brown (2021) Financial chatbots
- Isabella Ghassemi Smith (2019)
- Josephine Wäktare Heintz (n.d.) Cleo copywriter
- Smaller startups have created digital companions such as Replika (fig. 8), which aims to become your friend, by asking probing questions, telling jokes, and learning about your personality and preferences - to generate more natural-sounding conversations.

Design Implications

This chapter looked at AI in general since its early history and then focused on AI assistants in particular.

Table 54: Design implications arising from this chapter.

Category	Implication
Voice Assistants	There are many distinct ways how an algorithm can communicate with a human. From a simple search box such as Google’s to chatbots, voices, avatars, videos, to full physical manifestation, there are interfaces to make it easier for the human communicate with a machine.
Sustainability	While I’m supportive of the idea of using AI assistants to highlight more sustainable choices, I’m critical of the tendency of the above examples to shift full environmental responsibility to the consumer. Sustainability is a complex interaction, where the producers’ conduct can be measured and businesses can bear responsibility for their processes, even if there’s market demand for polluting products.
Sustainability	Personal sustainability projects haven’t so far achieved widespread adoption, making the endeavor to influence human behaviors towards sustainability with just an app - like its commonplace for health and sports activity trackers such as Strava (fig. 9) -, seem unlikely. Personal notifications and chat messages are not enough unless they provide the right motivation. Could visualizing a connection to a larger system, showing the impact of the eco-friendly actions taken by the user, provide a meaningful motivation to the user, and a strong signal to the businesses?

Category	Implication
Machine Learning	All of the interfaces mentioned above make use of machine learning (ML), a tool in the AI programming paradigm for finding patterns in large sets of data, which enables making predictions useful in various contexts, including financial decisions. These software innovations enable new user experiences, providing an interactive experience through chat (chatbots), using voice generation (voice assistants), virtual avatars (adds a visual face to the robot).
Character Design	I'm a digital companion, a partner, an assistant. I'm a Replika." said Replika, a digital companion app via Github CO Pilot, another digital assistant for writing code, is also an example of how AI can be used to help us in our daily lives.
Psychology	Humans respond better to humans?
Psychology	Humans respond better to machines that into account emotion?
Open Source	For public discussion to be possible on how content is displayed, sorted, and hidden, algorithms need to be open source.
User Experience	User experience design (AI UX) plays a crucial role in improving the consumer to investing journey. The missed opportunity to provide an even more interactive experience in line with user expectations.
LLMs	Prompt engineering findings have significance for "green filter" as it validates the idea of creating advanced prompts for improved responses. For "green filter", the input would consist of detailed user data + sustainability data for detailed analysis.
Cuteness	Cuter apps have higher retention?
Transparency	Understanding algorithm transparency helps humans to regard the AI as a machine rather than a human
Anthropomorphism?	

Sustainable Finance

The Journey from Consumer to Investor

Digital financial technologies (aka fintechs) enable new modes of interaction design which increasingly blur boundaries between shopping, saving, and investing, giving users exposure to investment opportunities through familiar activities that may have the potential to boost financial literacy and entice consumers to learn more about financial markets. Shopping, saving, and investing are converging on the same digital banking platforms, with features such as reward and cashback programs (Rakuten), round-up to next dollar with automated micro-investing (e.g. Acorn, Stash, Swedbank), and retail investing (Robinhood, Public) and copy-trading (eToro) into various (fractional shares of) stocks, derivatives like CFDs and futures, microloans (Kiva), commodities and precious metals such as gold and silver (Revolut), physical assets such as real estate, land, forest and digital assets such as cryptocurrencies, NFTs, and other alternative assets.

Digital money in its various forms connects industries on the same apps, which make investing more accessible and socially engaging, appealing to younger people who are active in social media and online shopping. Added to that the trend of sustainability, how can sustainability become more accessible? People want to shop, save, and invest sustainably - how to do it?

The Democratization of Financial Markets

trend. good news.

Legislation

- PWC (2020) Changes to laws and regulations aimed at achieving climate change mitigation is a key driver behind the wave of ESG adoption. The goal of these laws, first adopted in the European Union, a self-proclaimed leader in eco-friendliness, is to pressure unsustainable companies to change towards greener practices, in fear of losing their access to future capital, and to create a mechanism forcing entire environmentally non-compliant business sectors to innovate towards sustainability unless they want to suffer from financial penalties. On the flip side of this stick and carrot fiscal strategy, ESG-compliant companies will have incentives to access to cheaper capital and larger investor demand from ESG-friendly investors.
- House of Commons (2002): Already in 2001, the UK government was discussing ways to promote sustainable investment “fundamental changes in VAT or corporation taxes could be used to promote greener consumption and investment”.
- European Parliament (2014) Directive 14 2014/65/EU, 2014: The European Union fully recognizes the changing financial landscape trending towards the democratization of investments: “more investors have become active in the financial markets and are offered an even more complex wide-ranging set of services and instruments”.
- Kenton (2020): Some key legislation for investors has been put in place recently, for example “MiFID II is a legislative framework instituted by the European Union (EU) to regulate financial markets in the bloc and improve protections for investors”. European Securities and

Markets Authority (2017): “MiFID II and MiFIR will ensure fairer, safer and more efficient markets and facilitate greater transparency for all participants”.

- Anon (n.d.j) Taxonomy of sustainable activities in the UK
- Anon (2023al)
- Quinson (2020-08-31T17:00:13.652Z, 2020-08-31T17:00:13.652Z, 2020-08-31T17:00:13.652Z)
While the larger trend is for governments to adapt to and work towards their environmental climate commitments and public demand, the sovereign risk remains an issue. For example, the policies supported by U.S. President Trump during his presidency ran counter to many sustainability recommendations, including those directed at the financial markets. Helping legacy industries stay competitive for longer through subsidies, and lack of regulation, or even regulation supporting legacy technologies.

There's literature suggesting it's possible to make investments that both make an attractive financial return and adhere to sustainability goals. In housing development, there's evidence of 'green' buildings achieving a 'higher financial return than conventional buildings, both in terms of rent and sale price' (Oyedokun (2017)). There's also a trend of investors looking for sustainability in addition to profits in a few countries.

- For example - In Sweden "Preferences for sustainable and responsible equity funds
- Lagerkvist et al. (2020) undertook a choice experiment with Swedish private investors.
- Smith (2019) suggests 74% of Chinese youth are looking for "positive impact".
- Lingewaran (2019) suggest philanthropy is on the rise in Asia however Ho (2019) counters investors are not sure how to separate sustainable assets from less sustainable ones.

Financial and Sustainability Literacy

Financial and Sustainability Literacy are intertwined.

How can finance enable/help/encourage sustainability?

Sustainable Capital Allocation Methods

Shopping, saving and investing are forms of capital allocation. In one way or another, we're giving our money to companies that provide the products and services we need. The critical question is: do we choose to support sustainability-focused companies or those that pay less attention to sustainability?

Money is created by governments by law: using central banks, which loan money to commercial banks. New types of money is also created by companies and individuals using cryptography on blockchain-based distributed databases, which keep track of transactions (who-paid-whom). Whatever the method of creation, in essence, money is a *system of trust* where *something* is used as a *medium of value exchange* and accepted by *other people* as payment.

Increasing Number of Asset Classes

There are many asset classes only some of which would be accessible to a retail investors.

- The main categories of investment products are, based on the Anon (n.d.ap)

Investment Product
Stocks
Bonds
Mutual Funds
ETFs
Insurance Products such as Variable Annuities

Thematic Capital, Build a thematic portfolio. There's a wide range of investment products marketed as *sustainable*, however many of them are fake (**CITATION**).

Community Investing Enables Financial Inclusion

- Inexperienced investor can copy other people when investing.
- You don't know how to invest? Build an investing community? Can follow others and raise capital together.
- Savings in CO₂ Equivalent Emissions: CO₂ savings are the amount of CO₂e reduction one manages to achieve by changing one's behavior and influencing others (people, companies). While the individual footprint is so small, the largest reduction will come from influencing large groups of people, either by leadership, role-model, or other means.
- In some ways community-investing competes with robo-advisors as communities can be led by professional investors and followed by less sophisticated investors. Investor communities can have the type of ***social proof***, which robo-advisor do not possess.

Fintech

The user interface and user experience (UI/UX) of consumer-focused investing apps in Europe has improved over the past decade. The changing landscape is related to the earlier availability of better quality apps available in the US and the disappearance of the 1st generation of investing apps and the lessons learned.

In the early days in Europe, Germany and the United Kingdom led the way with the most robo-advisory usage (Cowan, 2018). While Germany had 30+ robot-advisors on the market in 2019, with a total of 3.9 billion EUR under robotic management, it was far less than individual apps like Betterment managed in the US (Bankinghub, 2019). Already in 2017, several of the early robo-advisors apps have shut down in the UK (AltFi, 2017). ETFmatic gained the largest number of downloads by 2017, focusing exclusively on exchange-traded funds (ETFs), tracking stock-market indexes automatically, with much less sophistication, than their US counterparts (AltFi, 2017). The app was bought by a bank in 2021 and closed down in 2023 (AltFi, 2021; Silva, 2023; Anon, 2023g).

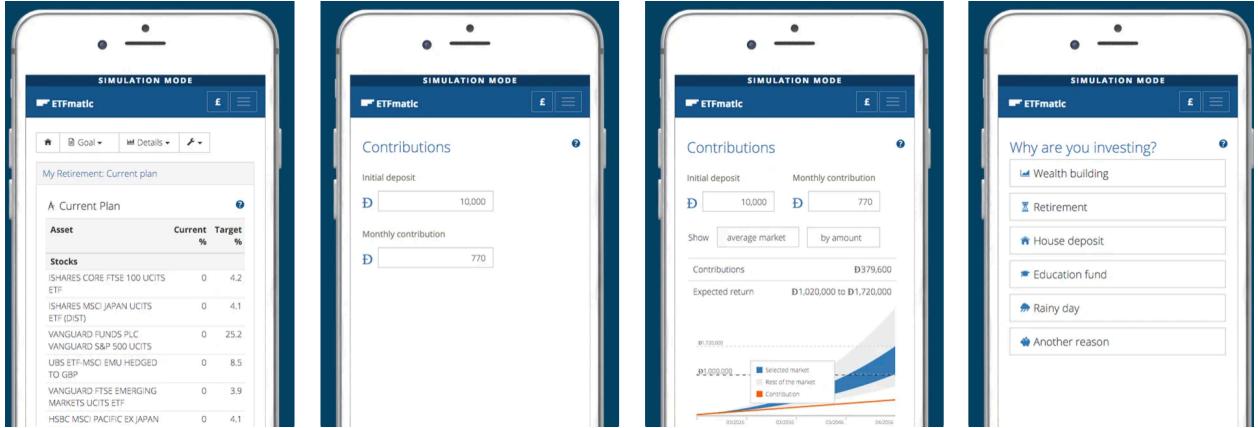


Figure 12: Out-of-date user interface of a European AI-Advisor ETFmatic in 2017 which was closed down in 2023 (Photo copyright ETFmatic)

- While the financial AI companion apps in the US market are ahead globally, they are not yet using many of the user experience innovations that are prevalent on social media platforms targeted at Generation Z and/or Millennials, possibly presenting an opportunity for cross-industry knowledge transfer, from businesses that are traditionally closer to the consumer - such as retailers. Financial AI companion apps have not yet grown to mainstream scale in Asia, Africa, Latin America, and Europe, being for the moment a largely US-based retail investor trend. The apps outside of the US are niche products in a nascent stage, however, they still provide relevant design directions or stories of what to avoid.
- Anon (2021p)
- Sean McGowan (2018)
- ROBIN DHANWANI (2021)
- Anon (2021d)
- Cordeiro & Weevers (2016)
- Ungrammary (2020)
- Bhatia, Chandani & Chhateja (2020) For example, in India, research is being conducted on how AI advisors could assist with investors' erratic behavior in stock market volatility situations, albeit without much success. India had more than 2000 fintechs since 2015 (Migozzi, Urban & Wójcik, 2023).
- Raha maraton etv investeerimissaade.. raadios on ka mingi saade
- Gamestop for climate massively collaborative investing by gen-z?
- But there's so much capital in large funds retails investor money doesn't matter at all. does retail money make any difference?
- Anon (n.d.s): digital assets bank
- Anon (n.d.bt): Crypto bank
- FINMA (2021) First crypto fund

- Anon (2023w) calculate climate cost
- Anon (n.d.af)
- swissinfo.ch/urs (2022) “More than half of the Swiss banks plan to offer digital assets services over the next few years.”
- Hyde (2006) Money as a gift

Robo-advisors is a term that was in fashion largely before the arrival of AI assistants and has been thus superseded by newer technologies.

- Ideally, robo-advisors can be more dynamic than humans and respond to changes quickly and cheaply. Human advisors are very expensive and not affordable for most consumers. Capponi, Ólafsson & Zariphopoulou (2019) argues “The client has a risk profile that varies with time and to which the robo-advisor’s investment performance criterion dynamically adapts”. The key improvement of personalizing financial advice is understanding the user’s dynamic risk profile.
- Robo-advisors compete with community investing such as hedge funds, mutual funds, copy-trading, and DAOs with treasuries. Robo-Advisor do not have the type of social proof a community-based investment vehicle has. The question is, does the user trust the robot or a human.
- John Ssenkeezi (2022): Small stock investments
- Financial empowerment
- Small cash apps like African market Investment Clubs Invest in sustainability with people smarter than myself
- Anon (n.d.bg)
- Qayyum Rajan (2021) ESG pulse
- Anon (n.d.az) Network for Greening the Financial System
- SmartWealth (2021) How do consumer become investors? marketing materials say: “One of the greatest hurdles to financial independence is a consumer mindset.” One of the greatest hurdles to sustainability is a consumer mindset?
- Outlaw (2015)
- Malliaris & Salchenberger (1996) (**Need to pay for paper!**)
- Anon (n.d.m) Huawei
- Consumption is ruining the world thinking as an investor the investor mindset
- Anon (2023aj) Personalised portfolios
- Anon (n.d.aq) Thai finance app
- Anon (n.d.bs)
- Renato Capelj (February 16, 2021 6:47 PM)

Crypto

Brazilian (N=573) “Crypto investors in Brazil are generally younger, male, and exhibit higher risk tolerance compared to non-crypto investors.” Colombo & Yarovaya (2024) “Brazil’s planned adoption of CBDC (Central Bank Digital Currency).” “It finds that risk tolerance, economic pessimism, and a belief in better investment acumen are significant predictors of crypto investment.”

Cryptocurrencies are the most popular financial action among young people (ADD CITATION) yet in some ways crypto needs even more financial literacy than traditional financial assets.

- Centralized Crypto Exchanges are in essence lending assets from the user. “The piece of the settlement aimed at getting important information to customers is more understandable from a retail protection standpoint. Customers who lend crypto assets to a company in exchange for a promised return should get the information they need to assess the risks against the rewards” (Hester M. Peirce, 2022).
- Taiwan bans buying cryptocurrencies with credit card because the volatility makes it similar to gambling (David Attlee, 2022; 廣編企劃, 2022).
- Volatile national currencies lead people to find other assets to hold.
- Crypto enables financial innovation and financial engineering by anyone with some programming skills.
- People like Turkey losing 75% of the value of their assets when currency collapses, why people buy crypto.
- Anon (n.d.o) estimates over 600 million cryptocurrency users worldwide
- Raido Tõnisson (2022a) Estonian bank selling Metaverse cryptocurrency Sandbox
- Marten Põllumees (2022) retirement funds invested in crypto
- Raido Tõnisson (2022b) due to a law change Estonian could take out their pensions and invest or spend them however they wanted.

DAOs

Decentralized Autonomous Organizations (DAOs) which have an investable treasury may be compare to Hedge Funds as a collective form of investing. Because of the on-chain nature where transactions are visible to anyone, they may be seen as more transparent. Typically DAOs have a voting system to make decision while Hedge Funds may be more centrally controlled. Also, the legislation affecting each would be different as hedge funds are an older and more established financial tool whereas DAOs still fall in somewhat of a gray area.

- Anon (2023ai) DAOs to enable concerted action towards climate goals using the pooled resources in a treasury, a blockchain (on-chain), similar to how hedge funds work.
- Carra Wu & Chris Dixon (2021) DAO consumer to investor
- Lucas Matney (2022)
- BlockChannel (2017)
- Anon (n.d.ao): Crypto investment clubs canceled
- Anon (n.d.al): Crypto crop insurance
- Social + NFTs - What would investing look like at the scale of 1 billion people

Oracles for Sustainability Data

Intersection with finance and Real World Data.

A data oracle is the concept of a source of real-world data which can be ingested through an application programming interface (API) to a blockchain system. There are many databases of sustainability information which could serve as an oracle for carbon labeling, packaging, transportation, consumption, and waste.

- Ethereum (2023)
- Caldarelli, Rossignoli & Zardini (2020) notes it's a challenge to ensure the accuracy and trustworthiness of real-world data from Oracles.
- Brady Dale (2021) and Chainlink (2022): The largest Oracle provider ChainLink founder Sergey Nazarov believes the collaboration of oracles and blockchains can make carbon credits more trustworthy.
- IPCI OpenLitterMap G.I.D Coin Regen Network
- dGen & PositiveBlockchain (2021): Positive Blockchain Database of blockchain for good projects

Regenerative Finance

- Anon (2023ak): What is Regenerative Finance (ReFi).
- Regen Network (22AD) and Regen Network (2023) regen network
- Smith (2021)
- Anon (2023r) KlimaDAO
- Anon (n.d.bh) Moss.earth
- Anon (n.d.bm)
- naturalinvest (2020)
- Marquis (2021)

The Gargantuan Eco-Investment Gap

bad news.

How Much Money Is Needed?

It would be easier for large institutional investors to move their money to sustainable assets than for retail investors to move their relatively small investments.

Sustainability lacks Trillions of USD in investment - even with massive financing going into sustainability, there's still a lack of investing. The estimate for the global *financing gap* for low-carbon energy production was 5.2 Trillion USD as of 2016 (Anon, 2016; Earth Day, 2023). A newer United Nations Environmental Programme (UNEP) calculation lowered the world needs an additional **4.1 Trillion USD** of financing in nature-based solutions by 2050 to meet climate change, biodiversity, and land degradation reduction targets (UNEP, 2022). According to (The Rockefeller Foundation, 2022) a slightly lower **2.5-3.2 Trillion USD** would be sufficient.

The needed investment doesn't seem so large - around 2.5-5.2 % of the global GDP - if one compares it to the *per year* Global Gross Domestic Product (GDP) estimated at around 100 Trillion USD in 2022 and growing to 105 Trillion USD in 2023 (Aaron O'Neill, 2023; International Monetary Fund, 2023). In essence, the estimated total investment gap in climate fits into the economic growth of 1 year of the global economy.

“Sustainable development requires more investment in sustainable companies and less in unsustainable firms.” (Van Zanten & Rein, 2023).

Investors' belief in sustainable investing is affected by other investors (Luz, Schauer & Viehweger, 2024).

What if 10% of annual consumer spending – *ten percent is about \$2,8T* - went towards protecting our climate?

The theme for the 2023 Earth Day was “*Invest In Our Planet*”.

The lack of funding in green energy especially affects emerging economies (Anon, 2022i). “*We can and must channel private capital into nature-based solutions. This will require policy and regulatory support, catalytic capital and financial innovation*” argued the CEO Green Finance Institute, Dr Rhian-Mari Thomas, ahead of COP27 in Egypt (Anon, 2023n). It's not happening fast enough.

Table 56: Comparative data on needed climate investment and other valuable assets; all figures in Trillions of USD (S&P Global, 2019; Grand View Research, 2021; Aaron O'Neill, 2023; International Monetary Fund, 2023; Stephanie Aaronson & Aaron Tilley, 2023; Statista, 2023b, 2021; SIFMA, 2023; US Treasury, 2023; Rao, 2023; Thinking Ahead Institute & Willis Towers Watson, 2023; Blockworks, 2023a, 2023b; McKinsey & Company, 2023; Oguh & Oguh, 2023; Fox, 2023; Trucost & TEEB for Business Coalition, 2023)

High-Value Assets (Trillions of USD)

Global Real Estate (2020, valuation)	\$326T
Global Equity Markets (2023, valuation)	\$108T
Global GDP (2023, per year)	\$105T
Global GDP (2022, per year)	\$100T
<i>Global Pension Funds (2023, valuation)</i>	\$47.9T
U.S. Equity Markets (2023, valuation)	\$46.2T
U.S. National Debt (2023, valuation)	\$32.6T
<i>Millennials Inheriting Money from Parents in the U.S., U.K. and Australia (2022-2032)</i>	\$30T
Global Retail Sales of Goods and Services to Consumers (2023, per year)	\$28.2T
GDP of U.S.A. (2023, per year)	\$26.8T
GDP of China (2023, per year)	\$19.3T
Global Private Market Assets (2023, per year)	\$11.7T
<i>Unpriced Externalities (2023, per year)</i>	\$7.3T
Global E-Commerce Sales (2021, per year)	\$5.2T
<i>Missing Climate Investment (2022, total)</i>	\$4.1T
Industrial & Commercial Bank of China (2019, total assets)	\$4T
Global Real Estate Sales (2021, per year)	\$3.7T
Apple Computers (2024, market value)	\$3.1T

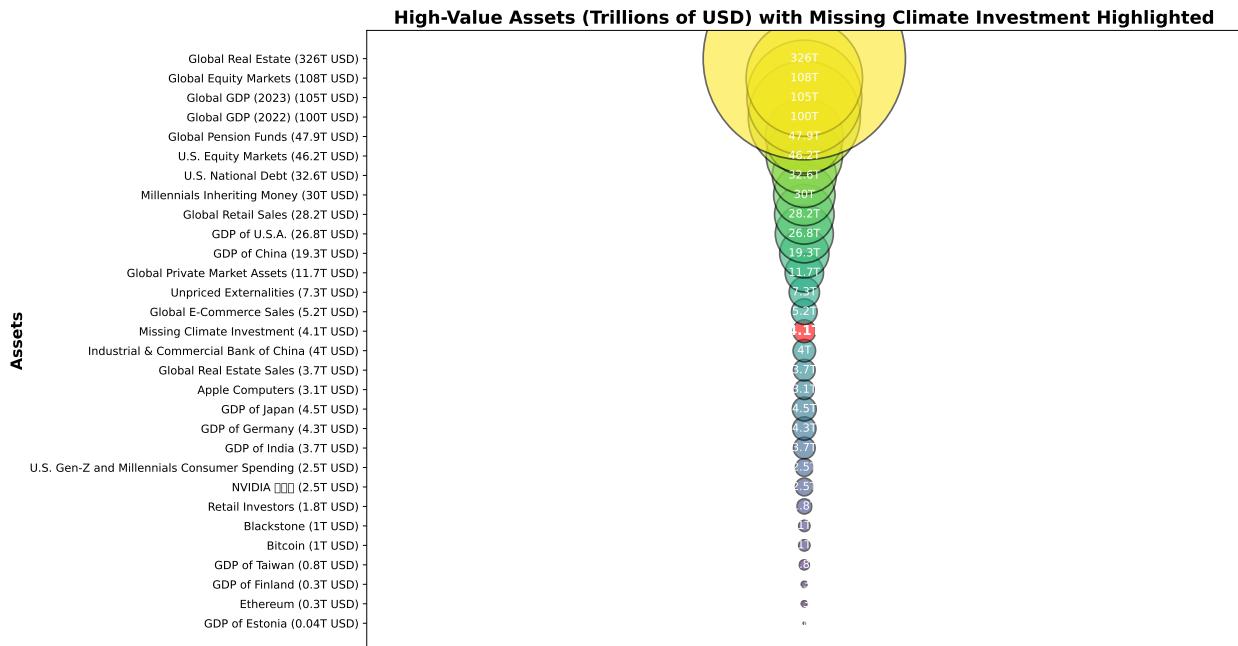
High-Value Assets (Trillions of USD)

GDP of Japan (2023, per year)	\$4.5T
GDP of Germany (2023, per year)	\$4.3T
GDP of India (2023, per year)	\$3.7T
U.S. Gen-Z and Millennials Consumer Spending (2022, per year)	\$2.5T
NVIDIA 英偉達 (2024, market value)	\$2.5T
<i>Retail Investors (2023, liquid assets)</i>	\$1.8T
Blackstone (2023, total assets)	\$1T
Bitcoin (2024, market cap)	\$1T
GDP of Taiwan (2023, per year)	\$0.8T
GDP of Finland (2023)	\$0.3T
Ethereum (2024, market cap)	\$0.3T
GDP of Estonia (2023, per year)	\$0.04T

While these assets and GDP values reflect different aspects of the global economy, the comparison illustrates that redirecting a relatively small fraction of global wealth and economic activity towards sustainable investments can close the investment gap. This perspective should inspire confidence that the goal is achievable with coordinated effort and policy support.

- Robeco survey of 300 large global investors totaling \$27T under management found biodiversity-protection is increasingly a focus-point of capital allocation (Robeco, 2023).
- Ray Dalio puts the needed climate investment at \$5T yet believes these financial goals won't be met Ray Dalio (2023)
 - – compliance and GenAI in banking: (Rahul Agarwal et al., 2024).
 - “Lessons from banking to improve risk and compliance and speed up digital transformations” (Jim Boehm et al., 2021).

Slightly more fun way to look at this data.



The Economics of Decoupling Growth from Environmental Degradation

Eco-economic decoupling

New Metrics

The first two decades of the 21st century have seen increasing economic thinking, looking to challenge, improve or upgrade capitalism to match our current environmental, social, and technological situation, often called *New Economics*. Some of these include behavioral economics, sustainable capitalism, regenerative capitalism, doughnut economics, ecological economics, blue economy, degrowth, attention economy, gift economy, intent economy, among others. There's no lack of published books on changing capitalism, which goes to show there's readership for these ideas. Build a new economic theory is out of scope for my thesis design, however I'll focus on the parts of economic theory I believe are relevant for *interaction design*-ing for sustainability.

There are those looking for *new metrics*. One of the first innovators, already in 1972, was Butan, with the *Gross National Happiness Index (GNH)*, which in turn inspired the UN, decades later, in 2012, to create the International Wellbeing and Happiness Conference and the International Happiness Day(Ribeiro & Lemos Marinho, 2017; Kamei et al., 2021). The Wellbeing Economy Alliance (WEAll) countries (New Zealand, Iceland, Finland, Scotland, Wales) as well as the EU and Canada, started the coalition in 2018 (Ellsmoor, 2019; David Suzuki Foundation, 2021; CEPR, 2022; Scottish Government, 2022; Wellbeing Economy Alliance, 2022). The World Bank talks about the comprehensive GDD+ metrics in its Changing the Wealth of Nations report (World Bank, 2021). Giacalone, Mattera & Nissi (2022) looks at wellbeing of Italian communities and proposes a new composite index. The award-winning economist Mariana Mazzucato argues in Gupta (2020) we have to include more into how we value unpaid labor, relating to the social (S in ESG) (Mazzucato, 2018).

Econometrics is the science and art of measuring the economy. The creator of the Gross Domestic Product (GDP) metric in 1934 Simon Kuznets said: “The welfare of a nation can scarcely be inferred from a measurement of national income as defined by GDP...Goals for ‘more’ growth should specify of what and for what” (United States. Bureau of Foreign and Domestic Commerce, Seventy-Third Congress & Kuznets, Simon, 1934). GDP was the culmination of previous work by many authors, beginning with William Petty in the 17th century Rockoff (2020). This long journey underlines how a metric about a complex system such as the economy is continuous work in progress. There has been ongoing work to create improved metrics such as the Sustainable Development Goals (SDGs), Human Development Index (HDI), Genuine Progress Indicator (GPI), Green GDP, Inclusive Wealth Index, and others (Bleys & Whitby, 2015; Kovacic & Giampietro, 2015; Anielski, 2001). Measuring wellbeing in addition to GDP and the metric should include resiliency dashboards, to visualize metrics beyond GDP and they are an integral part of country reports (GreensEFA, 2023). Similarly, the doughnut (donut) economics (more below) model calls for a “dashboard of indicators” (TED, 2018).

Ecological Economics is the prime suspect for eco-conscious ideas to incorporate into design, drawing attention to the interdependence of economy and the ecosystem; there are physical limits to economic growth on a planet with finite resources. The founder of the field Herman Daly was talking about *prosperity without growth* more than two decades ago, focusing on the diminishing natural resources (Daly, 1997). (Jackson, 2009, 2017) expanded on these ideas with recipes for a post-growth world, making the ideas seem more tangible and precise.

- Sacred Economics is used as-is as a framework and visualization tool.

Doughnut Economics

The doughnut (donut) is a simple visualization that helps to grasp the big picture of the economy and the physical and social worlds. It allows one to see the social shortfall and ecological overshoot of nations at the same time (Fanning et al., 2021). Doughnut Economics has not been implemented on a country-level however has inspired cities to take a comprehensive view of the doughnut of their own city.

Several EU cities have adopted the vision (Jordan G. Teicher, 2021). Doughnut in Brussels, Belgium. Everything has to be adapted to the place and context (Oikos Denktank, 2021; BrusselsDonut, 2022). The city of Amsterdam is developing shorter food chains (which save CO₂) and linking residents with food production and reconnecting people to the food. Food becomes a sort of ***social object***, which fosters collaboration in the community (Circle Economy, 2021). Amsterdam also has a Circular Economy Monitor which makes it easy for anyone to see the progress being made towards the Dutch goal to be a circular economy by 2050 (Waterstaat, 2019; Gemeente Amsterdam, 2022).

The Doughnut concept is a useful social object that's simple and deep at the same time, enabling starting conversations with people from all walks of life, independent of their politics leanings. As Raworth calls it, it's a ***“self-portrait of humanity in the beginning of the 21st century”***. Combining the SDGs inside the doughnut and the Planetary Boundaries outside the doughnut. The space donut represents a state of equilibrium and balance on spaceship Earth.

- Kate Raworth was inspired by ecological economics among other things.

- Bailey & Eggereide (2020) shows how the Norwegian government plans to increase salmon production 5x by 2050. How can this be sustainable?
- Gad Levanon & Michael Papadopoulos (2022) the donut effect is real, shift away from city centers. Not related to donut economy per se.
- Sala et al. (2020)
- Resource footprint, ecological footprint
- Oliver et al. (2022)
- Donut quantified Luukkanen, Vehmas & Kaivo-oja (2021)
- Defi Donut (2021) Savings Lottery
- Jolijn Hooghinkel (2023) donut essay winner
- International Development LSE (2021) Donut in practice
- BBC Reel (2020)
- Circle Economy (2021)
- city coalition Anon (2024a)
- Golias (2019)

Table 57: From Circle Economy (2021).

Short Food Chains in Amsterdam
Spatial planning for food place-making in the city
Circular agriculture
Regionally produced food
Collaboration between chain members
Food education

- Maria-Cristina Florian (2023)
- Wetenschappelijk Bureau GroenLinks (2023)
- 100 cities generate more than 70% of their electricity, circular city design
- Circular City Currency
- Earth's ecological ceiling
- Doughnut Economics Action Lab
- Raworth (2017) book
- Doughnut economics' BBC Reel (2020)
- Donut and Design Thinking both focus on sustainability and human-centeredness.
- Horwitz (2017) critics would say doughnut economics would expand the role of the government

Regenerative Capitalism

- Fuller (1983): “Nature is a totally efficient, self-regenerating system. If we discover the laws that govern this system and live synergistically within them, sustainability will follow and humankind will be a success.”

- Anon (2023y) “The quality of growth matters”. John Fullerton (2011): John Fullerton: Balance efficiency with resiliency so the whole system doesn’t become brittle and break. John Fullerton (2022): “human civilization is embedded in the biosphere”. Fullerton builds on the ideas of Club of Rome and Anon (1972).
- Triodos Bank
- Global Alliance for Banking on Values

Externalities need to be priced in

metrics and goals: ESG, SDGs,

- Celo’s protocol invests in carbon credits on the protocol level: Anon (2021c)
- Mazzucato (2021)
- Krausmann et al. (2018)
- Anon (2022p)
- support_ll (2021)
- Pauli (2017) Blue economy
- Standing (2022)
- Buller (2022)
- Pauli (2017)
- Lovins et al. (2018)
- Anon (2022s)
- CIRCL (2021)
- Michael Kramer (2012)
- Elkington (2020)
- Stockholm Resilience Centre TV (2017)
- Adam Smith: Interdependence

Debating Decoupling Economic Growth from CO2 Emissions

New economic thinkers are asking how can economic growth and sustainability be compatible. Some even ask if *economic growth* itself is the wrong goal? (Diduch, 2020). Degrowth is the most famous contender in that branch of economics. Is Decoupling Economic Growth and CO2e Emissions Possible? Is Green Growth an oxymoron? No-one knows as it hasn't been done before. Degrowth proponents are pessimistic it's possible to decouple greenhouse gas emissions from economic growth; historical data shows does not show any decoupling. Some data from China shows decoupling?

- (Keyßer & Lenzen, 2021) provides several scenarios for low, medium, and high levels of decoupling.
- (harrisson, 2019) concludes UK's CO2e emissions have fallen 43% from 1990 to 2017 through the use of less carbon-intensive energy sources and argues for moderate policies in (Hausfather & Peters, 2020). Meanwhile (Global Carbon Budget, 2023) data shows an increasing CO2e emissions trend in the UK in the same timeframe.
- Trucost, a company launched in 2000 to calculate the hidden environmental costs of large corporations and advance circular-economy practices was acquired in 2016 by S&P Dow Jones Indices, which by 2019 became a part of its ESG product offering (Toffel & Sice, 2011; Mike Hower, Dec 9, 2015 7am EST; Indices, Oct 03, 2016, 08:30 ET; Anon, 2019d). Its parent company S&P Global also acquired RobecoSAM's ESG rating business, consolidating S&P's control of ESG ratings (George Geddes, 2019).
- (Trucost & TEEB for Business Coalition, 2023) finds the value of unpriced externalities which are not included in the GDP is 7.3 trillion USD per year.
- The Progress Principle is a term coined by Teresa Amabile and Steven Kramer, says people like to see the number go up. Amabile & Kramer (2011)
- Capital misallocation
- Securitization
- In *intent economics*, could I define what are my expectations towards companies, before I engage in any transactions Searls (2012). Old-school businesses only expect me to spend money but I have so many more concerns. I'm human. I'm not just a piece of currency.
- In the context of this study, is it possible to make financial decisions that follow our guidelines and preferences but without moment-to-moment involvement needed so as to save up our precious time?

Shopping

Payments are an Entry Point and Source of Consumer Action Data

- Shopping Data
- From Payments to Investing
- The combination of consumption and investment is an access point to get the consumer thinking about investing. Even if the amounts are small, they are a starting point for a thought process.

- Payments is the primary way consumers use money.
- Payments is one way consumers can take individual climate action. In the words of a Canadian investment blogger, “every dollar you spend or invest is a vote for the companies and their ethical and sustainability practices” (Fotheringham, 2017).
- M-Pesa in Kenya since 2007 for mobile payments, used by more than 80% of farmers (Tyce, 2020; Parlasca, Johnen & Qaim, 2022). Using digital payments instead of cash enables a new class of experiences, in terms of personalization, and potentially, for sustainability. Asian markets have shown the fastest growth in the use of digital payments (McKinsey, 2020).
- In Sweden point of sales (PoS) lending is a common practice, and one of the reasons for the success of Klarna, the Swedish banking startup, which has managed to lend money to more consumers than ever, through this improved user experience.
- Taking out loans for consumption is a questionable personal financial strategy at best. If people can loan money at the point of sales, why couldn't there be 180 degrees opposite service - point of sales investing?
- A Dutch fintech company Bunq offers payment cards for sustainability, provided by MasterCard, which connects everyday payments to green projects, such as planting trees and donations to charities within the same user interface (Bunq, 2020). Sharing a similar goal to Alibaba's Ant Forest, Bunq's approach creates a new interaction dynamic in a familiar context (card payments), enabling customers to effortlessly contribute to sustainability. However, it lacks the level of gamification which makes Alibaba's offering so addictive, while also not differentiating between the types of purchases the consumer makes, in terms of the level of eco-friendliness.
- From Shopping to Investing Next Generation Customer Experience (n.d.) suggests “Targeted at millennials, Acorns is the investing app that rounds up purchases to the nearest dollar and invests the difference.”
- Anon (2023e) in Macau Contactless Payments:
- Commons, formerly known as Joro, analysis your financials to estimate your CO₂ footprint. Chant (2022)

Anon (n.d.ac) China was a money innovator introducing paper money in the Tang Dynasty (618–907 AD).

- Anon (2023c) Digital currencies make tracking easier
- E-Naira find papers
- Yahoo Finance (2022): WeChat, Alipay, vs digital yuan by Eswar Prasad
- MARISA ADÁN GIL (2022)
- Caio Jobim (2022)
- Digitalisation of payments creates lots of Point of Sale (PoS) data that would be valuable to understand what people buy.
- Anon (2022o)

People are concerned with digital payments

- Digital Currency Emele Onu & Anthony Osae-Brown (2022) reports how in order to promote eNaira use, the Nigerian government limited the amount of cash that can be withdrawn from

ATMs. “In Nigeria’s largely informal economy, cash outside banks represents 85% of currency in circulation and almost 40 million adults are without a bank account.”

- Jeff Benson (2022) “use the e-CNY network to increase financial surveillance.”
- democratize financial surveillance!
- Crypto tools allow you to look at any wallet already
- green transparency

Banks and Fintechs Capture User Data

Banks have access to each person’s financial habits which makes it possible to model sustainable behavior using big data analysis. Taiwan’s O Bank makes use of Mastercard’s data to calculate each transaction’s CO₂ emissions(Anon, 2022n).

- Banks have started offering a service to automatically save and invest tiny amounts of money collected from shopping expenses. Every purchase one makes contributes a small percentage - usually rounded up to the nearest whole number - to one’s investment accounts. For example, Swedbank (2022), the leading bank in the Estonian market, offers a savings service where everyday payments made with one’s debit card are rounded up to the next Euro, and this amount is transferred to a separate savings account. Similarly, the Estonian bank LHV (2020) offers micro-investing and micro-savings services, with an interesting user experience innovation showing how for an average Estonian means additional savings of about 400€ per year.
- While the financial industry is highly digitized, plenty of banks are still paper-oriented, running digital and offline processes simultaneously, making them slower and less competitive, than startups. Indeed, the new baseline for customer-facing finance is set by fintech, taking cues from the successful mobile apps in a variety of sectors, foregoing physical offices, and focusing on offering the best possible online experience for a specific financial service, such as payments.
- fundamental analysis such as the Piotroski F-score is not effective for startups because of high capital burn rates.

Banks and Fintech are becoming more similar than ever.

- 39% of Millennials are willing to leave their bank for a better fintech (n=4,282); innovation in payments helps retention (PYMNTS, 2023).
- The European Central Bank describes fintech as improving the user experience across the board, making interactions more convenient, user-friendly, cheaper, and faster. “Fintech has had a more pronounced impact in the payments market [...] where the incumbents have accumulated the most glaring shortcomings, often resulting in inefficient and overpriced products,” Yves Mersch, Member of the Executive Board of the ECB says in European Central Bank (2019).
- There are far too many **neobanks**, or challenger banks to list. The table only includes a small sample of banks and the landscape is even larger if one includes the wider array of fintechs. Neo-banks often use sustainability marketing.

- O bank carbon calculator (Brasil): “Consumer Spending Carbon Calculator” and “Low-Carbon Lifestyle Debit Card”

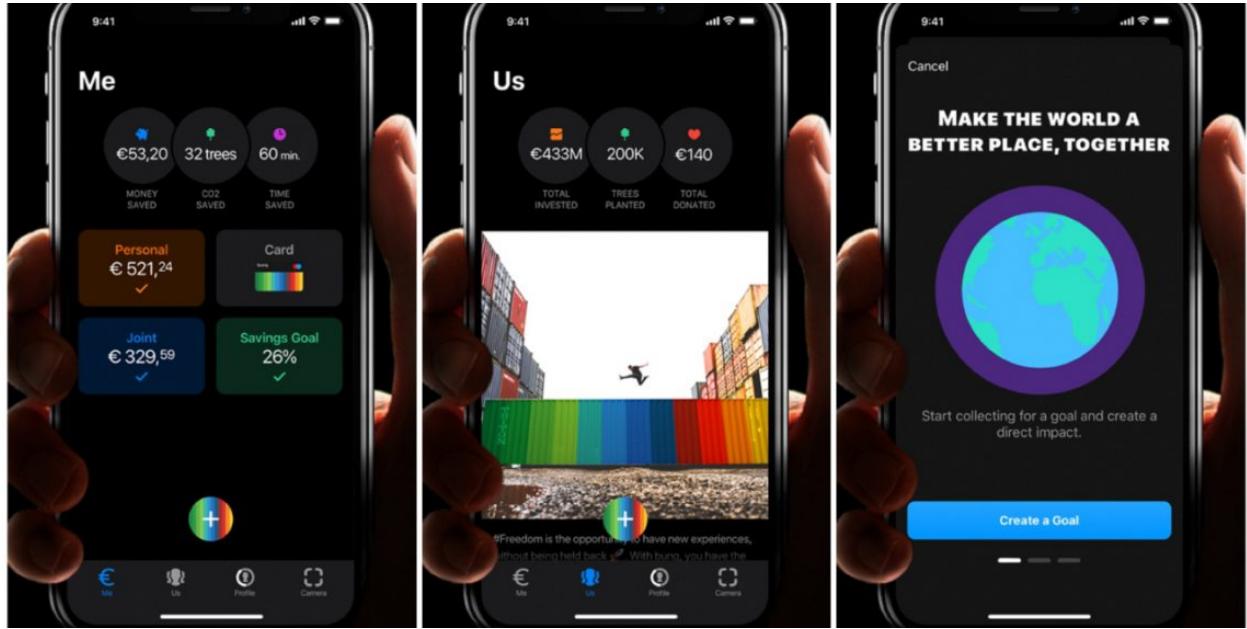


Figure 13: Bunq promises to combine banking and eco-friendly actions in the same user interface

- The following popular (totaling millions of users) robo-advisory apps combine sustainability, personalization, ethics, and investing (fig. 6) - however, they are mostly only available on the US market:

Table 58: Data from (Anon, n.d.cb, n.d.ax; Lightyear, n.d.; Anon, n.d.bi, n.d.ba; Monzo, 2023). An updated database is available at greenfilter.app/database.

Service	Features	Availability
Goodments	Matching investment vehicles to user's environmental, social, ethical values	USA
Wealthsimple	AI-assisted saving & investing for Millennials	USA, UK
Ellevest	AI-assisted robo-advisory focused on female investors and women-led business	USA
Betterment	AI-assisted cash management, savings, retirement, and investing	USA
Earthfolio	AI-assisted socially responsible investing	USA
Acorns	AI-assisted micro-investing	USA
Trine	Loans to eco-projects	USA
Single.Earth	Nature-back cryptocurrency	Global
Grünfin	Invest in funds	EU
M1 Finance	Finance Super App	US
Finimize	Investment research for anyone	US
NerdWallet	Financial clarity all in one place	US

Tomorrow Bank	Green Banking	EU
Marcus Invest	Robo-Advisor	US
Chipper	Digital cash app for African markets	Africa
Lightyear	Simple UI for Stocks, ETFs, interest from Estonia	EU
Ziglu	UK simple investing app	UK
Selma	Finnish investing app	EU
Monzo		UK
Nubank		Brazil
EToro		
Revolut	From payments to investing	UK, EU
Mos	Banking for students	
Robinhood		US
Mintos	Buy bonds and loans	EU

- Andrés Engler (2022)
- Tokenization is similar financial securitization which has been happening for a long time. - Art can be securitized and tokenized Masterworks (2023) - Blockchai makes this kind of financial engineering easier as any developer can do it; one does not need to be a bank.
- Given the large number of fraud cases in finance, *trust* is the number one concern for users (ADD CITATION). Good design is crucial for creating transparency, and transparency leads to trust.

Does Individual Climate Action Matter?

Consumer Activism

Conscious consumers make up a small percentage of the entire consumer public. (Milne, Villarroel Ordenes & Kaplan, 2020) coins the term *mindful consumers*, who do research and are aware of the impact of their shopping choices.

Sustainable Shopping

Is it possible?

Make use of indexes to compare companies.

- Weber (2021) proposes a sustainable shopping guide.
- Fuentes, Enarsson & Kristoffersson (2019) discusses package free shopping.
- van der Wal, van Horen & Grinstein (2016) discusses “status motives make people publicly display sustainable behavior”.

Shopping Footprint

Double Eleven celebrated on November 11th (11/11) is the world's largest shopping festival (時代財經, 2023). In June 2023, 526 million people watch e-commerce livestreams in China; online bargaining is a type of ritual (Liu, House & Kádár, 2024).

- - Legislation sets higher standards. (Anon, n.d.z) Ban polluting products campaign success story, EU shops can't sell deforestation products.
 - Shop CO₂e emissions for each company who i buy from? “get rid of brands”!! cause they hide and lie
 - Make commerce more transparent
 - Anon (2019b)
 - Sally Parker (2022)
 - “The sustainable market for Fast Moving Consumer Goods is 2.5 Trillion USD, that includes an untapped market opportunity worth 1 Trillion USD. Nearly 40% of customers say they would switch from their current preferred brand to one that offers more transparency”
 - Anon (n.d.ad)
 - Current shopping is like having a one-night stand. you barely know the name of your company. You don't know much about their background. Building consumer feeling of ownership, create meaningful connections between producers and consumers.
 - **AI alert:** “The company you've purchased from 3x in the past month is owned by Unilevel, which is under investigation for poor labor practices and deforestation”.
 - Sustainable Consumerism via Self-Regulation. 2M EUR project for the shopping app. (**gk-linglmayrSustainableConsumerismSelfRegulation2016?**)
 - EMILY WATERFIELD (2019)
 - Beebag shopping bags made of recycled plastic bottles with a NFC chip that works in conjunction with an app to provide rebates for customers. The Green Factor (2022)
 - Igini (2022) Online Shopping impact. Single's day, etc. Impossible to turn the tide?
 - “Asia is set to account for 50% of the world's total online retail sales”
 - What is the consumer CO₂ contribution? What is the target?
 - Konrad (n.d.) “an internet-wide directory of purchasable products, reminiscent of how the much of the world's music is made available on streaming platform Spotify.”
 - All the world's product directory
 - Austin Ryder (2020) Define your habits: are you consumer or investor?
 - “Learn to notice so we can preserve”, “Õpetame märkama, et oskaksime hoida”
 - Franklin Templeton Distributors, Inc (2021)

- Consume pressure to advance ESG regulatory standards to add a baseline ESG dynamic pricing of risk like climate, mandatory climate disclosures, carbon pricing knowing your supply chain, analyze supply chain risk
- **Live more sustainably with 10 minutes per day.**
- McKinsey (2022b) Inclusive consumer
- “Consumers have increasing power. Where we put our money reinforces certain types of businesses, as conscious consumers we can vote with our dollars. How can we do it? Sustainable brands, ESG, etc, etc. Pushing higher Standards and choose companies that adopt circular design”
- Anon (2021r) and 活動通 (n.d.) Cradle to Cradle Nordic circular design in Taiwan
- McKinsey (2022a)

Saving

People will only save nature if it also saves money.

Anthropomorphism

- Money in a “Safe” place: Money anthropomorphism increases saving behavior Wang, Kim & Zhou (2023)
- Mobile money users are better at saving Naito, Ismailov & Kimaro (2021)
- Design Implication: make saving money look like an avatar or piggy bank or smth.

Loyalty Schemes

help consumers save money and business increase repeat business. Building customer loyalty is a key part of repeat business and financial predictability for any company. Large consumer brands like Starbucks have for long ran successful rewards programs that encourage customers to come back (Steinhoff & Zondag, 2021). Could loyalty schemes create a pathway to investing in the company to strengthen the feeling of connection with the business even further? After all, I’m now a minority owner! Yet in practice, many consumers lack the financial literacy for investing and there are many legislative difficulties for turning loyalty points into investments. It’s easier instead to create a separate cryptocurrency or token program which users could collect and redeem for some benefit.

- **Patagonia** “Worn Wear” program
- **H&M** “Garment Collecting” program
- **The Body Shop** “Return, Recycle, Repeat”

Saving Precedes Investing

There are two ways to look at sustainable savings and this chapter is going to look at both of them.
1) Savings in CO₂e emissions 2) Savings in the financial sense of the word.

- Pension funds are some of the largest asset holders and choosing where to invest one's pension can be a sustainable financial action.
- College students might not have a pension fund yet.
- Bank inside of WhatsApp for the underbanked gig workers in Latin America: <https://www.kontigo.lat/>

Investing

- From building loyalty to building ownership, the first step is to start saving money to invest. How to encourage savings in daily life and make it a part of the everyday payments experience? Even starting with a small step, gathering a small target amount per month for savings, has the potential to shift the user's way of thinking about money. The second step, choosing where to invest these savings, will help us begin thinking like an investor. To start noticing trends and looking into how finance shapes the world.
- The As You Sow NGO aims to champion CSR through building coalitions of shareholders and taking legal action, including the Fossil Free Funds initiative which researches and rates funds' exposure to fossil fuels finance and its sister project Invest in Your Values rates retirement plans offered by employers (mostly US technology companies) (As You Sow, 2024a, 2024b)
- Burkart (2022)
- Savings and Investing are conflate into the same chapter because the large majority of savings that people have are invested by their banks. Thus the question of *sustainable savings* comes one of where exactly are they invested and what is the impact of that investment of sustainability.
- Assumptions: — where to put money makes a difference to sustainability. i.e. it matters what we buy, what we save, and where we invest
- Investing is a stronger signal to business than interactions on social media. Design Stakeholder capitalism. In future company every company should get a sustainability plan. this can be a push in that direction if companies with a sustainability plan become more competitive because of higher consumer demand.
- Hypothesis?
- Savings are the money one has in a pension fund or managed by themselves. For the majority of people, savings are invested by the bank and make up the largest proportion on investments for the people who are not active investors themselves.
- Anon (2023s)
- “Environmental savings”, “means the credit incurred by a community that invests in environmental protection now instead of paying more for corrective action in the future. If there is no way to estimate environmental savings for a particular project, then the amount of” (see Yale Center for Environmental Law & Policy, 2018) and (Anon, n.d.bz:p.33).

- Anon (n.d.t)
- Ethical Savings
- Anon (2023h)
- Anon (2019c)
- Anon (n.d.bu)

Young investors are typically ***retail investors*** investing small amounts of money for themselves. (Unless they work in an institution such as an investment firm, university endowment, pension fund or mutual fund, and have a say in where to invest large amounts of other peoples' money.)

Retail investors face many challenges in comparison with their institutional counterparts. For instance, they may have much less time to do proper research, face information asymmetries, where finding good information is limited by time, ability, as well as financial literacy, whereas professional investors have the tools, skills, time, and knowledge, to make better investment decisions.

- Information evavōrdsus between pro and novice investors
- OpenSea (2022) Taiwanese digital influencers as NFTs.
- *For young people, investing mostly means buying cryptocurrencies?*
- Koreans investing in influencers? Koreans investing into media personalities: Yuqing Zhao (2021)
- An open question is whether young investors are more easily than professionals swayed by ***influencers***? Influencers are terrible for investing... but? Sustainable investing, kids watch TikTok lizlivingblue (n.d.)

Influencer - crypto twitter connections

- There are many groups of Twitter, Reddit, and elsewhere, where investing trends start, causing more volatility
- Copy-investing is a popular feature of retail investing platforms like EToro
- Irene Zhao (2022)
- Investing is a fundamentally hopeful act. It means I think there's a future. Specifically, 'green investing' is investing in the future of our planet - but can we trust the sustainability practices the 'green' investment vehicles aggregate, promising to have a positive impact? For example, the European Union for many years counted biomass as 'green' energy, even while forestry companies were cutting down trees to produce the biomass - the regulation was not specific enough to curb this practice. So, in effect, a 'green investor' might be supporting deforestation. How can an easy-to-use investment app address such complexities without alienating the users?
- The world will be very different in 30 years - it's time to invest in services that make our societies resilient, able to robustly respond to rapid change. Research and product development go hand-in-hand; the outcome of this study can provide insights for new financial product and service development. Related to SDG 9: "Build resilient infrastructure, promote sustainable industrialization and foster innovation". The complexity of the situation offers an opportunity for design to make it understandable for humans

- In 2021 the Estonian government decided to free up mandatory retirement savings so people can exercise their own judgment on how to invest (or spend it). Financial analysts are worried the Estonian population will spend their retirement savings right away - instead of investing.
- Gary Gensler (2022) Investor protection, making investing accessible, climate risk disclosure
- Anon (n.d.as) Crypto DeFi education
- Anon (2021l) *Swedish green fintech (important article)*
- Anon (2021e) Doconomy Business footprint

Indices

Sustainability indices need transparency and standardization (Bolognesi et al., 2024).

Personalized Investing

- 2022 saw a wave of new platforms aiming to make investing easier for retail investors
- One example is Revolut, which expanded from a simple payments app to support varied saving and investment types (Anon, 2023aa) and (Anon, 2023q).
- Twitter (now X) is becoming a financial app.
- Inspiration from WeChat.
- Nerdwallet's Tommy Tindall (2023) suggests making financial commitments instead of resolutions.
- How can the mobile devices which the majority of us are carrying with us every day, help us make decisions about the businesses we engage with? In terms of user experience, can personalized AI advisors empower our financial actions from shopping to saving and investing?

Retail Investing is Financial Inclusion

Retail Investing can be seen as a form of financial inclusion. Ant Group's CEO Eric Jing says in Turrin (2021): “*The financial system of the past 200 years was designed for the industrial era and served only 20% of the population and organizations. As we enter the digital age, we must better serve the remaining 80%*”.

- Tan (2020) proposes “*financial ecologies*” to understand the dynamic relationships between various actors: investors, advisors, government, where the government plays an active role in growing financial inclusion and responsible financial management. However, the paper further suggests that current robo-advisors (available in Singapore) make the investor captive to the agency of AI, making the person lose agency over their financial decisions.
- Li et al. (2022a) suggests retail “investor attention can significantly improve enterprises' green innovation level”
- Celo and Impact Market

- MicroLending
- Retail Investor Helpers: A wide number of banks are offering services marketed as sustainable. It's hard to decide.
- *Design implication: As a user, I can use the app to compare banks available in my country*
- Rupert Jones (Mon 7 Feb 2022 07.00 GMT)
- Jackson (2020)
- Stef (2019)
- Anon (2023t)
- Seeking Alpha (2020)
- Marko (2022)
- Consumer debt in the USA
- Nubanks, also known as challenger banks.

Company
SPARQAN
Robinhood

Green Bonds

- Sustainability Linked Bonds: What this?
- In 2017 the Malmö city in Sweden released green bonds to finance a sustainable transition of the city []
- Anthropocene Fixed Income Institute (AFII) (2022): Aramco, Saudi Arabian public petroleum and natural gas company ‘Fake green bonds’ under scrutiny.
- Shashwat Mohanty (2022): “sustainable funds don’t buy Zomato’s ESG narrative”
- Priscila Azevedo Rocha, Akshat Rathi & Todd Gillespie (2022): “Sustainability-linked bonds let companies borrow cheaply if they meet environmental, social, and governance targets. A Bloomberg News analysis found those goals are weak”
- (Priscila Azevedo Rocha, Akshat Rathi & Todd Gillespie, 2022) suggests “*So far, most ESG investing is in the stock market. But the \$22 trillion corporate bond market, where mature global companies such as Chanel go to borrow money from investors, has a particularly powerful role to play. Companies rely on debt much more than they do on stocks.*”
- Green Bonds ESG data needs to be visualized Passive Investing Why focus on PI instead of daily investing like Robinhood?

- 257 billion USD worth of green bonds issues annually in 2019, expected to reach 1 trillion usd by 2030 MacAskill et al. (2021)
- China has the 2nd largest green bond market in the world; buyers are looking for green bond certification to reduce yield spread, meaning the price of the green bond is becoming more similar to the price of a ‘regular’ bond (Li, Zhang & Wang, 2022).
- Chinese *green bond market* is growing fast (Peng & Xiong, 2022).

Hedge Funds

- While hedge funds used to be available for professional investors, *smart contracts* make it possible to create decentralized organizations which pool member resources for investing.
- Nathan Reiff (2023)
- Ian Bezek (2021)
- BlackRock (n.d.) notes some ESG-oriented hedge funds can be “highly engaged with management teams” in order to influence management towards ESG practices in said companies”
- Anon (2021f)
- Hedge (2023): Make a hedge fund with your friends
- Most successful investor invest together
- Angelist

Green Investment Platforms

Such as “green shops” there are green investing platforms, green ETFs, etc. All of these are essentially forms of branding designed to make it easier for investors to find an investing product they trust.

There are many ‘green investment platforms’ who to trust?

Name	Description	Link
Trine		trine.com
The Many		the-many.com
Sugi		sugi.earth
ClimateInvest		clim8invest.com
Circa5000		circa5000.com
FairOwn		fairown.com

- Hankewitz (2021)
- Investing - Your investment fund’s ESG thesis investing thesis investing expert investing thesis research

- Investing thesis
- Open Banking: “Open Banking offers massive potential for improving online customer experience. That potential starts with the payment experience, which then generates a positive ripple effect through the entire customer journey.” investing into good companies

Divesting

- The inverse of investing.
- In institutional finance, the Norwegian \$1.3T USD sovereign wealth fund (the world’s largest, followed by China)[^5] started a divestment trend in 2016 by divesting from coal. Their plan to reach net zero CO₂e nonetheless only targets 2050. Furthermore, who would be the counterpart for such large transactions? The fund also announced divesting from Russia after its invasion of Ukraine, however has yet to sell any shares citing lack of buyers on the Moscow stock market. University of California also followed suit with divestment of its \$126B USD portfolio from oil and gas.

Benchmarks

“Make benchmark methodologies more transparent when it comes to ESG & put forward standards for the methodology of low-carbon and ESG benchmarks in EU.”

https://finance.ec.europa.eu/sustainable-finance/disclosures/eu-labels-benchmarks-climate-esg-and-benchmarks-esg-disclosures_en

Indexes

Indexes Enable Comparing Companies. Indexes make comparison possible. There are many-many Indexes, Scoring Systems, Ratings, Certifications, etc.

- Rating Systems: Companies assess customer’s credit score, however how can customers rate companies.
- ESG Shopping: “Changing our relationship with money”
- Nordic Climate Transparency Leadership: “companies with higher quality climate reporting also provide higher returns”

Certification

Does certification matter? Consumers are willing to pay more for bio-based products “72% of Europeans are willing to pay more for environmentally friendly products. The study identifies a “green premium” and a “certified green premium,” indicating increased WTP for bio-based and certified bio-based products.” Morone et al. (2021) (need access)

- consumer awareness of Sustainable supply chains, Italian consumers have a strong preference for antibiotic-free meat (Mazzocchi et al., 2022).

Rating System

B Corporation
ESG
Fair Trade
Responsible Business Index
Greenly

There are many different certifications

- Anon (n.d.x)
- B Impact Assessment
- sustainable brands
- Fair Trade
- Anon (2023ag) For example, the Green Web Foundation certifies how sustainable is the web hosting used by websites.
- Anon (n.d.v) Responsible business index
- Testing website CO₂ emissions Wholegrain Digita (2023)
- Greenly Decarbonization Index Greenly (2023)
- ESG Criticism “25 ESG ratings from three major providers (Moody’s Analytics, MSCI Inc., and Refinitiv)” - “well-rated companies do not emit significantly less carbon than those with lower scores.”
- ESG reports are very general and opaque. We need product-level analytics and reporting to be able to compare products.
- Product-level reporting can be a basis for investing in companies. “Product-investing”. I want to invest in particular products.
- Google Environmental Insights Explorer enables local governments (cities) to measure CO₂ emissions and enact environmental policies that optimize city functions such as traffic flows (Anon, n.d.aw; Nicole Lombardo, 2021)
- ESG apps in Singapore:
- DBS LiveBetter consumer sustainability app (DBS Singapore, n.d.; DBS, 2018)
- <https://www.gprnt.ai/>

ESG Compliance Systems: - MEET - EXCEED - LEAD

Existing rankings

- Earth.Org (2022)
- Staff (2021)

References	What it does
LeafScore (2023)	Leafscore for product
Anon (n.d.x)	Ethical consumer ratings

- Frances Schwartzkopff (2022b) “Companies in industries with the biggest carbon footprints aren’t reporting how their emissions feed into financial risk, according to an analysis of corporate reports by the Carbon Tracker Initiative.”
- Fashion brand ratings
- B Impact Assessment
- Ethical Shopping
- Anon (n.d.bw) Largest consumer goods companies

B Corporations

B Corporations undergo strict assessment and adhere to stringent sustainability practices.

- Anon (n.d.ab) BCorporation listings by country
- Anon (2017a)
- Citywealth (2021)
- Anon (n.d.bl)
- RavenPack (2021)

Product Databases

All of the world’s products are subject to one or another standard and although they are not uniform, there’s some documentation existing about every product.

- Anon (n.d.bd): Open Knowledge Foundation’s Open Product Data website shut down
- Håkon Bogen (2016): “Is there a global database of all products with EAN 13 barcodes?”
- GS1 (n.d.) EAN/UPC barcodes on most consumer products
- Semantics3 (2017)
- World product database
 - Anon (n.d.p): “open product database”
 - Anon (n.d.by) green tech database
 - Anon (n.d.be) packaging database

Standards

(International Trade Centre, 2022) currently lists 334 different sustainability standards: “Towards a meaningful economy” “The world’s largest database for sustainability standards”, “We provide free, accessible, comprehensive, verified and transparent information on over 300 standards for environmental protection, worker and labor rights, economic development, quality and food safety, as well as business ethics.”

- Most sustainable companies. Make a database?
- Anon (n.d.bp)
- Anon (n.d.bc) app for nutrition and sustainability data

ESG Crisis

- ESG greenwashing Baldi & Pandimiglio (2022)

ESG Needs Standardisation

- Environmental, Social, and Corporate Governance (ESG)
- Since the 1970s, international bodies, governments, and private corporations have developed sustainability measurement metrics, the prominent one being ESG (Environmental, Social, and Corporate Governance) developed by the UN in 2005. This rating system has already been implemented or is in the process of being adopted on stock markets all over the world and has implications beyond the stock markets, allowing analysts to measure companies' performance on the triple bottom line: the financial, social, and environmental metrics.
- In Taiwan, the Taipei stock market has listed ESG stocks since 2017 and was hailed by Bloomberg as a regional leader in ESG reporting (Grauer, 2017), while Nasdaq Nordic introduced an ESG index in 2018, and Euronext, the largest stock market in Europe, introduced an ESG index and a series of derivative instruments in the summer of 2020 (Euronext (2020)).
- Doorn (2020): Many ecologically focused funds with different approaches have been launched in recent years, with variations in asset mix and style of management. Thematic asset management is expected to grow, with investors packaging opportunities based on consumer trends.
- Kirakosian (Noveber 16, 2020) Digital payments and circular bio-economy, even using tactics such as co-branding with famous individuals.
- Jersey Evening Post (2020) A recent example is one of the largest private banks in Switzerland, Lombard Odier & Co, when they launched a thematic bio-economy fund inspired by the words of The Prince of Wales, 'Building a sustainable future is, in fact, the growth story of our time'.
- Reid (2020) ESG gives banks a new tool to market and sell environmentally conscious opportunities to institutional investors, for example, universities - a case in point being the recent partnership between HSBC and the University of Edinburgh.
- PWC (2020) PWC suggests "asset managers educate their staff and client base. 'It will be critical to build stronger ESG expertise among their employees by up-skilling existing staff on ESG principles and strategically scout for and integrate more diverse and ESG-trained talent'".
- The advice consultancies are providing to banks establishes a common language and helps banks to sell strategical alignment for long-term institutional sustainability in terms of finance, social, and governance.

- For AI-powered assistants to be able to provide guidance, metrics are needed to evaluate sustainable assets, and ESG provides the current state-of-the-art for this. The largest obstacle to eco-friendly investing is greenwashing where companies and governments try to portray an asset as green when in reality it's not. A personal investing assistant can provide an interface to focus on transparency, highlighting data sources and limitations, to help users feel in control of their investment decisions, and potentially even provide large-scale consumer feedback on negative practices back to the business through infringement discovery.
- ESG companies don't emit less CO₂ than non-ESG companies.
- <https://www.openesg.com/> because you can't trust ESG (Aikman, 2022) !
- ESG is filled with greenwashing
- ESG is a really low bad
- Sest ei saa ESG ja teisi mõõdikuid usaldada, crowdsourced mõõdikud
- Q: Reflection on the ESG wave: Does a company that performs well in carbon reduction but whose products are harmful to health conform to the spirit of ESG?
- Improving ESG Accessibility
- ESG risk
- Implication for design: ESG can't trusted.
- In Taiwan, the *FTSE4Good TIP Taiwan ESG Index* tracks ESG-rated companies on the Taipei stock market (Taiwan Index, 2024).
- Margaryta Kirakosian & Angus Foote (2022) suggests “Disparity between ESG methodologies was one of the key hurdles to finding the right sustainable strategy.”
- Trading ESG futures?? because climate is slow it makes sense to trade de climate future
- CFI2Z4 tracks Carbon Emissions Futures (Investing.com, 2024)
- While ESG is riddled with problems, it has started a common language and there are many ways how to improve it
- Gov launching ESG funds. Why is this important to research now? People in their twenties should invest in their future. Millennials and younger generations like services with a green, eco-conscious focus.
- Anon (2022c)
- Given our combined power (I'm a Millennial) with Generation Z, we are willing to pay more for sustainable products [^8].
- While promising to become sustainable, oil companies are increasing production Noor (2023); Sunak, UK Prime Minister announced 100 new licenses for oil drilling in the UK.
- Other large university endowments, such as managed by Yale, Stanford and MIT are in decision gridlock[^6]. Blackrock, the largest private investment fund in the world with \$10T USD under management, released guidance reflecting their plans to shift their investments to vehicles that are measured on Environmental, Social, and Governance (ESG) performance [^7]. However they later backed off from their decision.

- Banks are required by law to apply the principle of Know Your Customer (KYC).
 - **Feature:** How could people apply the same principle (**Know Your Company**) when buying a product or investing? Would building an ESG community help push polluting companies towards greener practices? - or starving them from cheap access to capital.
 - It can be as mundane as choosing the next eco-friendly product instead of the polluting one we purchase in the supermarket make a difference? How to invest in the growth of companies that put ESG at the center of their activities instead of using it for greenwashing? Creating direct ties will improve ESG. A journey from consumption to investing, in line with users' personal values, by providing relevant sustainable finance guidance. x ##### ESG Crisis
 - James Phillipps (2022) and Anon (2023j) ESG Not delivering on it's hopes
 - TEDx Talks (2022) large corporations are using ESG for greenwashing by investing in token-projects but not changing their fundamental polluting practices.
 - Margaryta Kirakosian (2022)
 - Banks are hiding emissions related to capital markets, which is a major financing source for oil and gas projects Wilkes (2023)
 - Daily (2021) best ESG list
 - ESG UAE FutureESGInvesting
 - Sanjai Bhagat (2022): Not better environmental performance, ESG poor performance
 - Simões-Coelho, Figueira & Russo (2023) Coca Cola ESG
 - PIETRO CECERE (2023) calls ESG labeling confusing and arbitrary.
 - ESG is a Marketing Tool
 - Gemma Woodward (2022) 8 problems with ESG
 - Agnew (2022) RIP ESG
 - Luo (2022) found firms with a lower ESG score are more profitable.
 - Analysis: Messari: investor education, information asymmetry
-
- Problems
-
- ESG is an annual report not realtime
-

Greenwashing Disturbs Sustainable Capital Allocation

Greenwashing is one of the largest blockers of sustainability; humans will feel as if choosing green is useless and give up. Both the European Commission and the Chair of U.S. Securities and Exchange Commission (SEC) Gary Gensler have called for more legislation to curb business greenwashing practices. *“If it’s easy to tell if milk is fat-free by just looking at the nutrition label, it might be time to make it easier to tell if “green” or “sustainable” funds are really what they say they are.”* says Gensler (US Securities and Exchange Commission, 2022).

Sustainable Investing is Based on Data

Sustainable investing is firstly about changes in legislation which set stricter sustainability standards on companies. Secondly, increased transparency, new metrics, and new tools make it feasible to differentiate more sustainable companies from less sustainable ones.

Upcoming EU greenwashing legislation hopes to curb misleading communications by companies. Until new legislation is in place (2030 in the EU), consumer awareness is crucial as currently most emission-reduction programs are voluntary and thus affected only by consumer demand (André & Valenciano-Salazar, 2022).

- Greenwashing is widespread in company social media communications (Geoffrey Supran, 2022). ClimateBert AI finds rampant greenwashing (Bingler, Kraus & Leippold, 2021; Sahota, 2021).
- For example Purkiss et al. (2022) highlights the confusion between compostable and biodegradable plastics and public misunderstanding what happens to these plastics when they reach the landfill: “[m]ost plastics marketed as “home compostable” don’t actually work, with as much as 60% failing to disintegrate after six months”.
- Napper & Thompson (2019): Shopping bags marketed as *biodegradable* don’t show deterioration after 3 years in salt-water sea environment ..
- Yu (2021) ESG is filled with greenwashing. Anon (2023b) several US states are introducing regulation for ESGs to curb greenwashing. Frances Schwartzkopff (2022a) suggests the ESMA and EU has strengthened legislation to counter ESG greenwashing.
- Greenwashing is a large detractor from environmental action as it’s difficult to know what is sustainable and what is not.
- Green investing only makes sense if it’s possible to distinguish sustainable investments from not sustainable ones.
- Sahota (2021): “thanks to other emerging technology like IoT sensors (to collect ESG data) and blockchain (to track transactions), we have the infrastructure to collect more data, particularly for machine consumption. By measuring real-time energy usage, transportation routes, manufacturing waste, and so forth, we have more quantifiable ways to track corporations’ environmental performance without relying purely on what they say.”
- Frédéric Simon (2020) and Kira Taylor (2021): While the EU has proposed legislation to curb greenwashing, EU climate policy itself has been criticized for greenwashing. Sometimes greenwashing comes under legislative protection. Booth (2022) describes how “A recent investigation shows illegal logging of protected areas in eastern European countries that supplies residential wood pellets in Italy. Belgium, Denmark, and the Netherlands are importing pellets from Estonia, where protected areas are logged for pellets and the country has lost its forest carbon sink, despite large-scale wood pellet plants being certified ‘sustainable’ by the Sustainable Biomass Program”. A number of new AI-based tools aim to find instances of greenwashing.
- Anon (2022b): Climate Bonds Initiative greening the \$55 trillion short-term debt market

- Marketing

Sustainability Marketing

- Ames (2022)
- The Muse Editors (2020)
- Shradha Bhatta (2021)
- Earth.Org (2022)
- Todd-Ryan (n.d.)

Realtime ESG

There's a growing number of companies helping businesses to measure CO₂e emissions in their product lifecycle.

- Kyle Wiggers (2022) proposes makersite, instant sustainability impact from supply chain.
- Makersite (n.d.) proposes ***product sustainability modeling***.
- Tim Nicolle (2021) “Real-time ESG data is more difficult to greenwash”, “supply chain is a significant source of ESG content”
- Automate CO₂ calculations realtime:
- Indrek Kald (2022): FlowIT automate CO₂ counting
- “Factory social score”.
- People working at the factories can report conditions
- Anon (n.d.u): “But the real breakthrough is how we can surface that real-time ESG data directly to individuals in the shops and online, linked to the products that they are browsing and potentially buying. This means that ESG change will finally be driven by the ultimate judge of business success – the customer.”

Governance or Corporate Responsibility

How are large corporations responding to the climate crisis?

Lack of leadership. (Capgemini, 2022): “Many business leaders see sustainability as costly obligation rather than investment in the future”.

The CEO of the Swedish clothing producer H&M - one of the largest fast-fashion in the world -, recognizes the potential impact of *conscious consumers* as a threat (Hoikkala, 2019).

Many large businesses have tried to find solutions by launching climate-focused funding. (Korosec, 2021) reports that Amazon's 2B USD to a Climate Pledge Fund earmarked to fix climate problems is invested in energy, logistics, and packaging startups, which will reduce material waste. “Good intentions don't work, mechanisms do,” Amazon's founder Bezos is quoted as saying in (Clifford, 2022). Walmart is taking a similar approach, having launched a project in 2017 to set CO₂ reduction

targets in collaboration with its suppliers Walmart (2023). These examples underlines how money marketed as climate funding by retail conglomerates means focus on reducing operational cost of running their business through automation and material savings.

Large corporations such as Nestle and Coca Cola support the biodiversity law to have a level playing field for business (Greens EFA, 2023).

- Anon (2013)
- Guidotti (2015)
- “Sustainability is important for many reasons including: Environmental Quality – In order to have healthy communities, we need clean air, natural resources, and a nontoxic environment.”
- Low, Baum & Sovacool (2022) finds considerable uncertainty exists among experts which CO2 reduction methods among nature-based and technology-based are the most effective.
- Pathways to drawdown

Slavery Still Exists and How to Trace Worker's Rights?

In 2023, an estimated 50 million people are still in slavery around the world; lack of supply chain visibility hides forced labor and exploitation of undocumented migrants in agricultural work; 71% of enslaved people are estimated to be women. (Kunz et al., 2023; Borrelli et al., 2023).

The UN SDG target 8.7 targets to eliminate all forms of slavery.

Slavery is connected to environmental degradation and climate change (Decker Sparks et al., 2021). Enslaved people are used in environmental crimes such as 40% of deforestation globally. Cobalt used in technological products is in risk of being produced under forced labor in the D.R. Congo (Sovacool, 2021). In India and Pakistan, forced labor in brick kiln farms is possible to capture remotely from satellite images (Boyd et al., 2018). In effect, the need for cheap labor turns slavery into a *subsidy* keeping environmental degradation happening.

- Christ & V Helliar (2021) estimates 20 million people are stuck inside corporate blockchains. The Global Slavery Index measures the ***Import Risk*** of having slavery inside its imports Walk Free (2023).
- Hans van Leeuwen (2023) slavery affects industries from fashion to technology, including sustainability enablers such as solar panels.
- “commodification of human beings”
- Anand Chandrasekhar & Andreas Gefe (2021): Trading commodities “Switzerland has a hand in over 50% of the global trade in coffee and vegetable oils like palm oil as well as 35% of the global volume of cocoa, according to government estimates.” Can traders have more scrutiny over what they trade?
- Modern Slavery Act.
- Another aspect of supply tracing is the treatment of workers and working conditions. Companies that intend to give supply chain a voice” by connecting workers directly to the consumer (even in anonymously, to protect the workers from retribution), include *CTMfile* and *Alexandria*.

- Anon (2022r) Worker Voice apps.
- Tim Nicolle (2021) and PrimaDollar Media (2021) PrimaDollar Realtime ESG Give supply chain a voice by connecting workers directly to the consumer.
- Matthew Gore, Alessio Sbraga & Joseph Malpas (2022) reports the International Maritime Organization (IMO) targets cutting CO₂ equivalent emissions in shipping 50% by 2050 compared to 2008.
- Sepandar Kamvar (2022) “A blockchain is a database without a database admin”
- Verra (2023) Verra new Methodology Announcement Webinar
- Eisenstein?: “Money is a technology”.
- Eisenstein (2011): 5 things, UBI, demurrage, ...
- Anon (2021b)
- Ganu (2021)
- Improve product *provenance*, blockchains offer this transparency

Transparency

- Anon (n.d.bj): Sites like Simply Wallstreet provide in-depth analysis: Simply Wallstreet also same for crypto
- Snowflake analysis like Simply Wallstreet

Design Implications

Category	Implication
	<p><i>As a consumer, I can get notified by the app about highlights of poor legislation refuted by science.</i></p> <p>ESG alone is not a sufficient metric to prove sustainability of a company and needs to be accompanied by other metrics.</p> <p>Anon (2019a): “Investors want to know where their money is going”, says Heike Reichelt, Head of Investor Relations at World Bank.</p> <p>This applies to both institutional and increasingly retail investors. Sustainable investing is possible due to consumer demand for greener products and services, and new tools such as ESG for measuring sustainable businesses and assets, as well as advancements in large-scale computational technologies to analyze large amounts of tracking data, comparing performance between different assets. Given these developments, might it be possible to create a practical sustainable investing AI advisor for consumers?</p>

Category	Implication
Greenwashing	<p>Sustainability is fragmented. How can billions of people find greener alternatives and build closer relationships with sustainability-focused companies? Greenwashing is widespread, how can we feel trust, honesty, and transparency? A research project for designing a sustainable shopping, savings, and investing companion.</p> <p>Reading EU Commission's proposals, one might think the politicians have everything under control, we can relax and continue the same lifestyles as before. Unfortunately, this is not true. As with ESG, while the good intentions may be there, the reality is emissions keep rising, while they should be falling. It's possible to curb greenwashing!</p> <p>Laws against greenwashing</p> <p>Fintech Like a Robinhood stock symbol page for brands including live ESG metrics and ability to register divestment. Same for crypto can be automated? - People will start to discuss ESG vs price discrepancy?</p> <p>hetkel hinna info liigub aga toidu kvaliteedi info ei liigu rohelise filter finding good quality products stock are disconnected from the products companies make</p>
Accountability	<p>What if we gave consumers the tools to keep companies accountable?</p> <p>As an interaction design student who cares about the environment, I ask myself how can interaction design contribute to increase sustainability? I make the assumption that investing is inherently “good” for one’s life, in the same way, that doing sports is good, or eating healthy is good. It’s one of the human activities that is required for an improved quality of life as we age - and started investing sooner, rather than later, is best because of the compound interest.</p> <p>Nonetheless, investment also includes higher risk than sports or food. How to communicate the risk effectively while educating the users?</p>

Category	Implication
Community	<p>Airbnb for Investments platform for projects linked to your consumption habits. Can provide better products for you as well as invest in these companies. The consumer can feel closer connection to the businesses they interact with through shared values, leads to participatory design and stakeholder capitalism. Platform to understand investment products. Green crowdfunding already allows people to invest into projects to make new green products, for example from recycled materials. but what about getting involved on a deeper level. Bigger than projects, scalable solutions. Kickstarter has green projects section. Startups vs large businesses. The design of the user interface helps the adoption of a new technology. What is the suitable user interface for millennial green investors?</p> <p>Feature: Make a climate hedge fund with friends</p> <p>Feature: Sustainable investing product for young people everyday use Crypto, NFT provide everyday excitement trend of young ppl in crypto retail investors without needing to pay bank fees</p> <p>Design: Feature: Help me write me investment thesis first. If corporate social responsibility (CSR) loyalty programs, driven by points systems are useful, can we go a step further, and create a pathway to enable the consumer to become an investor in the company they like to buy from? Could this strategy provide more meaning for the consumer, leading to higher customer retention, as well as financial returns?</p> <p>Where to invest for green impact? Which investment vehicles are the most suitable for green investments? When a person wants to make a sustainable investment, where to put your money if you want to make the world greener? If young people are worried about climate, why are they not investing in green assets? To what extent can interaction design increase market participants' engagement with sustainability? What are some suitable user interfaces for millennial green investors? Is design relevant to investing decisions? Direct investment AI assistant vs marketplace of existing investment products? But how to measure? Currently, there is no easy way to do it, and the UX of traditional banks is too cumbersome and old-fashioned. My research aims to find ways to enable a wider audience to access sustainable investment opportunities. This chapter gives an overview of the current (as of late 2020) sustainable investing landscape as well as future trends related to interaction design and user experience innovations (fig. 4).</p>

Category	Implication
Accessibility	<p>This research is concerned with how billions of people might exclude polluting companies from their lives and elect to support companies that put sustainability in the core of their business instead. Why does it matter? Individual sacrifice is too small to have a meaningful impact. For societal change, we need to pool our resources.</p> <p>How can ESG (environment, social, and governance) become accessible to our everyday experience, while avoiding greenwashing?</p>
Loyalty	<p>Loyalty to investment. What are the standard conversations about money and savings that I would traditionally have with a financial advisor, that could be converted into a portable, mobile form, in my pocket every day?</p> <p>Feature: We need a dashboard of comparable public indicators about each company.</p>

Methodology

Start with expert survey, then expert interviews (because so many questions from literature review).

Group	Task
Experts (Finance)	Interview
Experts (Design)	Interview
Experts (Sustainability)	Interview
Target Audience (College Students)	Survey + Prototype Testing

I adopted a face-to-face method to increase response rates distributing flyers to students on college campuses, canteens, and classrooms getting verbal permission from educators in their classrooms to distribute the survey flyer. The flyer included a colorful AI-generated visual with a futuristic game-link female figure, the title “climate anxiety survey”, a website link (ziran.tw) and scannable QR-code.

Similarly to (Liu et al., 2023a) I distributed the survey in schools in the Northern, Soutern, Central, and East regions of Taiwan.

The survey only included questions and descriptions in Chinese. I have used the Claude 3 Opus model to translate them to english for this table.

Table 66: 36 Likert Fields included in the survey

Original Question in Chinese	English Translation
如果你/妳懷疑你/妳要買的番茄可能是由強迫勞工（現代奴隸）採摘的，你/妳仍然會買它嗎？	If you suspect that the tomatoes you are going to buy may have been picked by forced labor (modern slaves), would you still buy them?
你/妳關心食安嗎？	Do you care about food safety?
你/妳 7 年內買車嗎？	Will you buy a car within 7 years?
你/妳 7 年內買房嗎？	Will you buy a house within 7 years?
你/妳購物時知道產品環保嗎？	Do you know if the products are environmentally friendly when you shop?
你/妳覺得認證環保的公司更好嗎？	Do you think companies certified as environmentally friendly are better?
你/妳支持肉稅嗎？	Do you support a meat tax?
你/妳關心食用雞的生活嗎？	Do you care about the lives of chickens raised for food?
你/妳避免吃肉嗎？	Do you avoid eating meat?
你/妳覺得你/妳花錢會影響環境嗎？	Do you think your spending affects the environment?
你/妳會對金錢感到焦慮嗎？	Do you feel anxious about money?
你/妳會對金錢很節儉嗎？	Are you very frugal with money?
你/妳會經常存錢嗎？	Do you often save money?
你/妳對自己的財務知識滿意嗎？	Are you satisfied with your financial knowledge?

Original Question in Chinese	English Translation
你/妳投資會考慮環保嗎?	Do you consider environmental protection when investing?
你/妳覺得台灣的經濟目標是增長嗎? 你/妳覺台灣的得環境退化是台灣的經濟增長的前提嗎?	Do you think Taiwan's economic goal is growth? Do you think environmental degradation in Taiwan is a prerequisite for Taiwan's economic growth?
你/妳覺得台灣的經濟增長有助於保護環境嗎?	Do you think Taiwan's economic growth helps protect the environment?
你/妳覺得經濟能不排 CO2 也增長嗎?	Do you think the economy can grow without emitting CO2?
你/妳覺得經濟增長有物質限制嗎?	Do you think there are material limits to economic growth?
你/妳會每天都用 AI 嗎? 你/妳會信任 AI 嗎?	Do you use AI every day? Do you trust AI?
你/妳想要 AI 有個造型嗎?	Do you want AI to have a specific appearance?
你/妳喜歡待在大自然嗎?	Do you like being in nature?
你/妳擔心氣候變化嗎?	Are you worried about climate change?
你/妳對環境污染情況會感到焦慮嗎?	Do you feel anxious about environmental pollution?
你/妳知道許多植物和動物的名字嗎?	Do you know the names of many plants and animals?
你/妳感覺自己和大自然很接近嗎? 你/妳努力實踐低碳生活嗎?	Do you feel close to nature? Do you strive to live a low-carbon lifestyle?
你/妳想做更多環保事嗎?	Do you want to do more for environmental protection?
你/妳對環境相關政治議題有興趣嗎?	Are you interested in environmental political issues?
你/妳信任碳排放抵消額度嗎? 你/妳的環保行動對環境保護有效果嗎?	Do you trust carbon offset credits? Do your environmental actions have an effect on environmental protection?
你/妳想在行業內推環保嗎?	Do you want to promote environmental protection within your industry?
你/妳得自己對新觀念開放嗎? 你/妳的大學對可環保性支持嗎?	Are you open to new ideas? Does your university support environmental sustainability?

Respondents who remained outside the survey parameters were disregarded from the data analysis.

Research Design

- Christian Rohrer (2022): Research methods

The research design of this study consists of 3 steps.

- Qualitative research targeted at financial and interaction design experts, leading to a *wish list* of features.
- Survey potential users' preferences, including a choice experiment of the proposed features.
- Design a prototype of the personal sustainable finance AI assistant, tested using qualitative methods in a focus group.
- This mixed-method research design is divided into three stages (fig. 11).
- My purpose for the first qualitative stage is to explore the general themes arising from the literature review related to the design of AI advisors for investing. I will identify specific user experience factors, through interviewing experts in financial technology and user experience design and reviewing existing applications on the marketplace. At this stage in the research, the central concept being studied is defined generally as expectations towards a sustainable investment AI advisor.
- I will then proceed to the second, quantitative stage, informed by the previously identified factors, and prepare a survey, including a Likert scale, and a choice experiment, focusing on the preferences of the potential users aged 18-35, living in Sweden and Taiwan (see fig. 12 on next page), exploring the relationship between independent variables: - "Interest in Sustainability" - "Interest in Investing" - "Preferred Features" - and the dependent variable "User Sign-ups".
- In the third stage, I will return to the qualitative methods, by building a prototype of the sustainable investing AI companion, taking into account insights gathered in the previous stage. I will use a focus group to discuss the prototype, and conduct a thematic analysis of the discussions' recordings, leading to further validation of previously gathered data and possible changes in the prototype. The gained insights, accompanied by the app prototype, which embodies my findings, will be the final outcome of my research.

Conceptual Framework

- The conceptual framework map (fig. 13) presents the key concepts arising from the literature review thus far in the research process. I'm using these concepts when developing interview strategies for phase one of the research, developing the survey questionnaire for phase two, as well as for building the Personal Sustainable AI Financial Advisor (PSAA) for young adults at the final stage of the process. However, I expect the conceptual framework to further evolve with additional findings while conducting my research.

Conceptual Model

Research Methods

Phase One - Qualitative Research

The qualitative research methods employed in the first stage of the research design enables me to explore concepts arising from literature review further, using a more open approach, without limiting the conversation only to pre-ascribed notions. The strength of the qualitative approach in the first stage is to encourage the discovery of new ideas, not yet common in literature and potential user experience factors related to sustainable investing and user experience.

Sampling

My qualitative sampling structure uses non-probability snowball sampling, with the following criteria: financial industry, fintech, and design experts everywhere, including in Taiwan and Sweden, but also Estonia, Portugal, and elsewhere.

Method: Semi-Structured Interviews

I will conduct exploratory research in English using semi-structured interviews recorded online and offline.

Phase Two - Quantitative Research

The strength of quantitative research is to enable me to access a larger sample of potential users in two countries, using online survey methods, and to validate some of the qualitative findings from stage one.

Sampling My quantitative sampling structure uses a judgmental criterion: age 18-35, located in Sweden or Taiwan, surveyed using an English-language online survey.

Method: Likert The survey includes a Likert scale between 1 to 7 to validate key findings from the first stage of the research by assessing responses to statements regarding the app's design, features, and other criteria that may still emerge.

Method: Choice Experiment The survey includes a choice experiment between different sets of potential features available when communicating with the sustainable finance AI companion.

Phase Three - Qualitative Research

In the last phase, I will return to the qualitative methods to further validate the quantitative findings from stage two. Here my focus will be on operationalizing the gathered insights into a prototype that users can experiment with and discuss with their peers in a focus group setting. Sampling

The phase three sampling structure uses a judgmental criterion: - age 18-35 - located in Taiwan - Using the English language for discussion

A focus group of 6 to 10 people will be gathered in Tainan. Because in-person presence is required in this stage, the prototype will only be tested by potential users physically present in Taiwan. To avoid convenience sampling, I will post online ads in English to invite people who I don't know personally, to participate in a "financial AI application testing group" (wording may change).

Method: Focus Group The strength of a focus group is the ability to observe potential users in a social setting, where knowledge can be exchanged between the participants. The whole experience, including emerging conversations, will be recorded and transcribed.

Method: Thematic Analysis Finally, I will perform a thematic analysis of the focus group transcriptions in order to validate previous findings, and open avenues for future research.

Results

Expected Findings

- During the preparation of this research proposal, I conducted a preliminary round of face-to-face interviews using 21 open-ended probing questions using a convenience sampling of NCKU students on campus between ages 19 and 29, a total of 12 respondents. The interviews lasted between 9 and 21 minutes and were conducted to get some initial feedback on my research idea, the respondents' daily routines, app usage, feelings towards financial questions, including investing, relationship with nature, and environmental sustainability. These preliminary conversations led me to emphasize more on the financial journey, i.e., to consider the importance of the shopping, savings, and payments apps students already use daily, which could serve as an entry point to becoming an investor. I expect my future research findings to confirm this initial idea and offer diverse ways and examples of what that path could look like in practice.

Survey Overview

import from Ziran

A survey of Taiwanese college students (excludes overseas Chinese-speaking students as well as foreign students) covering attitudes towards shopping, saving, investing, economy, nature, sustainability, and AI.

Survey Oct. 13th - Nov. 3rd, 2023

- 2000 cards with a QR code printed out
- Distribution conducted at 8 universities (handing out the cards)
- 1289 people started the survey, 518 quit
- 771 people completed the whole survey
- Data after filtering: 675 people aged 18-26 (Gen-Z), Taiwanese, current students in BA (large majority), MA (small minority) or PhD level (very few respondents)
- 36 likert fields (5-point scale) used for clustering the students into 3 personas with K-means clustering
- 14 product features (multiple-choice) used for K-modes clustering
- 4 choice experiments
- 2 option ranking questions
- 10 text fields used to enrich the personas

Data Analysis

- Use K-Means clustering for survey data. K-means clustering is similar to vector distances for similarity used in large-language models (LLMs) word embeddings and deep learning.

Findings

- Literature: AI assistants should integrate with Digital Product Passports
- Literature: AI assistants should show carbon label data.
- Literature: AI assistants should avoid taking ESG at face value (because it's a really low bar) and integrate other metrics such as B Corp.
- Literature: AI assistants should
- Literature: Do not make another investing app, make a sustainability filter for excising investing platforms.
- Literature: College students can support extended producer responsibility

How might AI assistants empower regenerative shopping, saving, and investing?

Display the ESG, EPR, B-Corp, etc, etc credentials for each product and investment. EPR and B-Corp are success stories which should be highlighted while ESG is largely discredited. There are many existing and ongoing approaches to sustainability. The best approach might be to plug into excising system and communities and legislation to support and empower them.

How might one design an intuitive sustainable shopping, saving, investing app?

- Apple Watch app

What app features might college students rate as the highest priority?

- Autopilot

How might one visualize ecological impact in digital product design?

- Accuracy is more important for human trust than actual impact.
-

95.9% used a mobile device, 75,5% using an iOS device (iPhone), 20.8% using an Android device.
design implication: should design mobile app (but apple is so restrictive)

RQ 1

- “the AI companion is informed by the latest scientific insights and can provide accurate, evidence-based recommendations .”
- “The AI is designed to offer personalized guidance by analyzing complex environmental data and translating it into user-friendly information, helping students make more sustainable choices in their daily lives .”
- “It explores various AI interaction designs, including chatbots, voice assistants, and virtual avatars, to find the most engaging and supportive formats for college students .”
- “address the “attitude-behavior gap” among college students by providing tools that make sustainable financial actions more convenient and impactful. ”

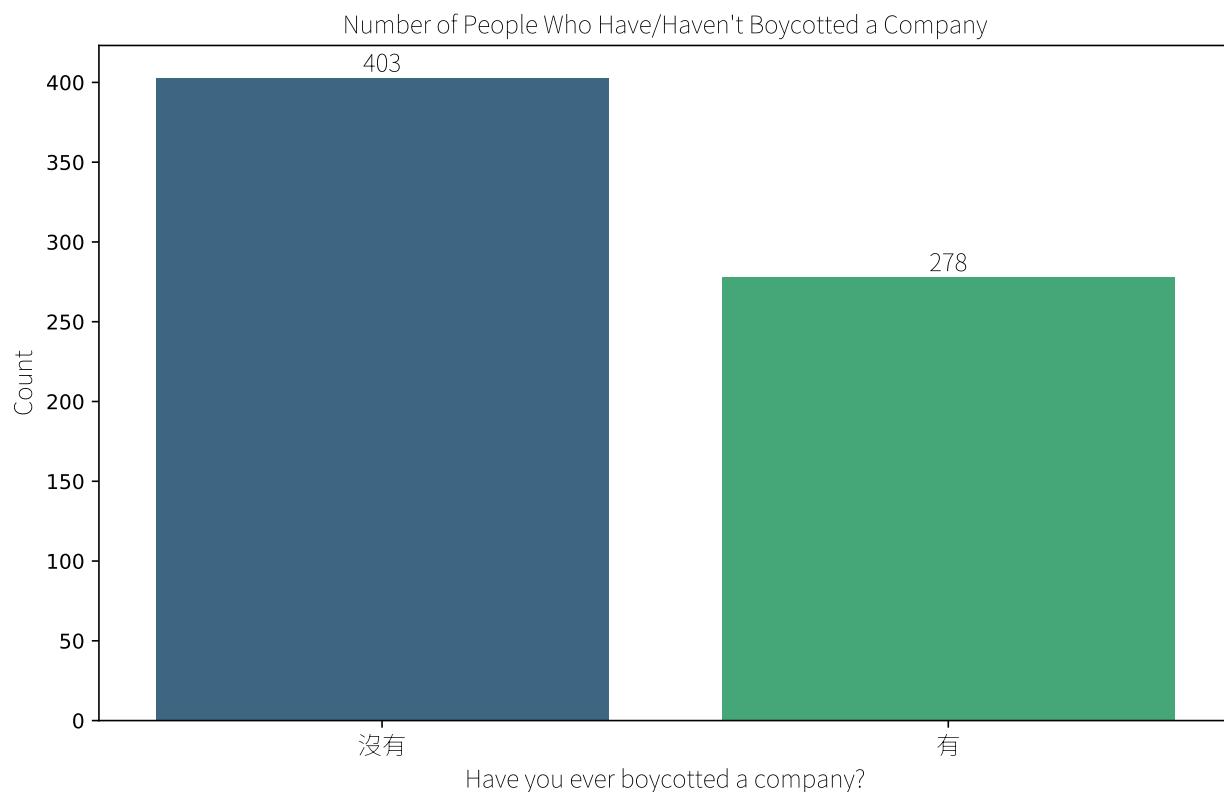
RQ 2

- “provide real-time information about the sustainability of products and companies”
- “AI companion includes features for identifying and investing in sustainable companies. This involves providing data on companies’ environmental, social, and governance (ESG) practices, and facilitating investments in green bonds and sustainable funds.”
- “shopping-as-investing,” where the AI links the act of purchasing sustainable products with investing in companies that produce these products, effectively merging consumer and investor roles.”

RQ 3

Shopping

Boycott Count (Overall)



Why Boycott

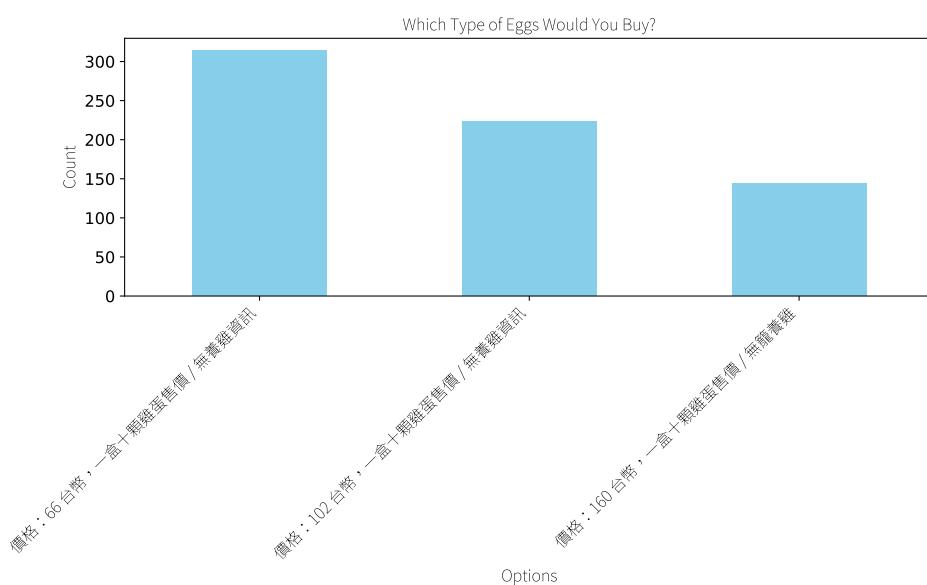
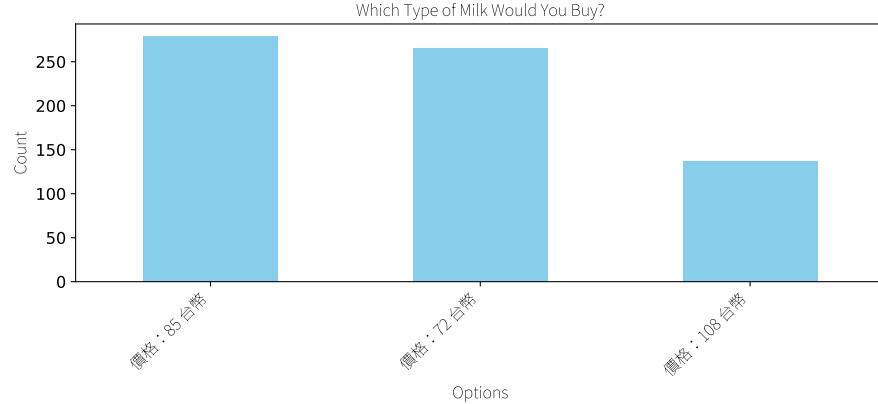
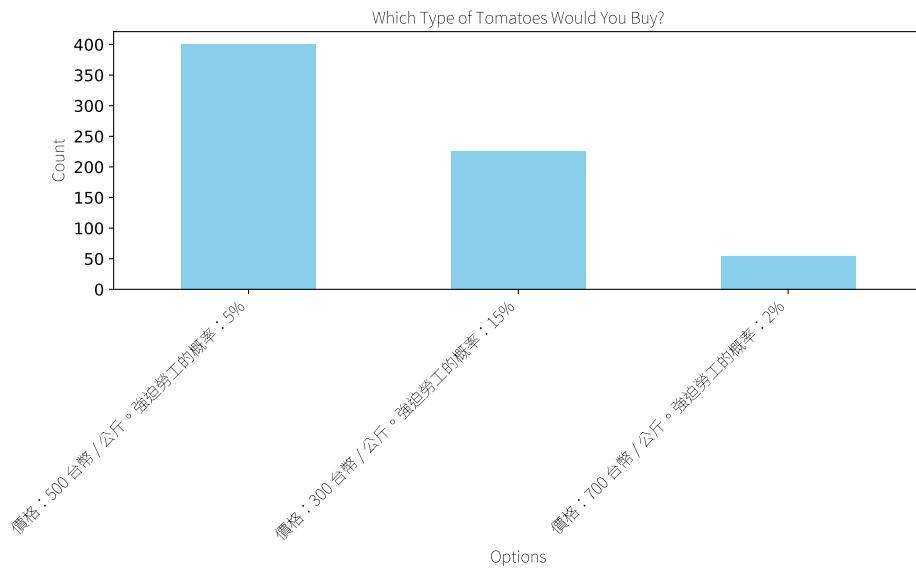
Reason	Count
0 食安問題	33
1 地溝油	10
2 黑心油	8
3 食安	5
4 政治因素	4
...	...
182 出事	1
183 因為食安與人權問題	1
184 因為有出新聞	1
185 此公司危害食安，以抵制這種行為讓公司更能意識到執行此行為的後果	1
186 因為這家公司壓榨員工	1

Trusted Brands

	Brand	Count
193	No trusted brand	329
194	Have but not specified	56
0	義美	42
1	Apple	9
2	光泉	7
...
188	Decathlon	1
190	心樸市集	1
189	Tony's chocolate	1
192	無印良品 MUJI	1
191	華碩	1

The following responses were counted as “no brand”: “無”, “沒有”, “沒有特別”, “□”, “目前沒有”, “No”, “沒”, “沒有特別關注”, “沒有特別信任的”, “不知道”, “無特別選擇”, “目前沒有完全信任的”, “沒有特定的”, “沒有特定”, “沒有特別研究”, “目前沒有特別關注的品牌”, “N”, “none”, “無特別”, “目前無”, “沒有特別想到”, “沒有固定的”, “x”, “沒在買”, “nope”, “一時想不到…”, “沒有特別注意”, “無特別的品牌”, “無絕對信任的品牌”, “不確定你說的範圍”, “還沒有”

Choice Experiments

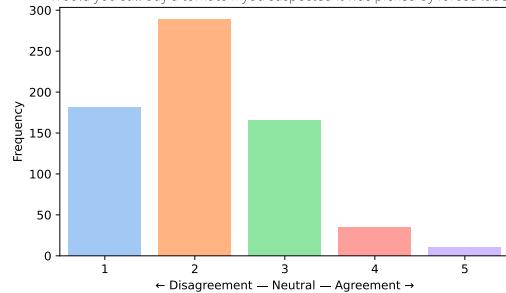


College Student Attitudes (Overall)

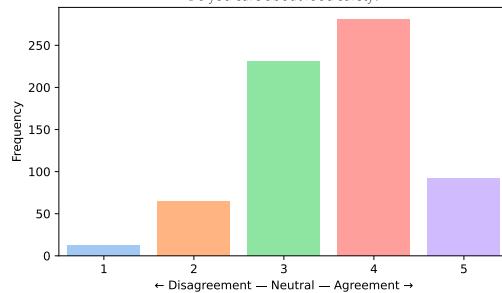
These are student attitudes across all 36 likert fields without clustering. Clustered results are available under the Personas section.

Shopping

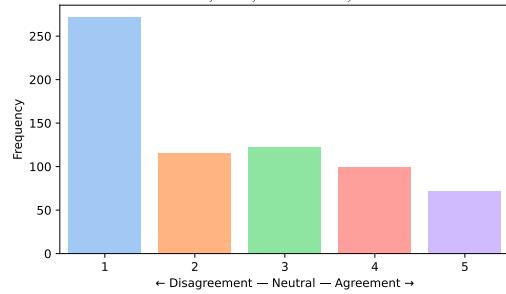
如果你/妳懷疑你/妳要買的番茄可能是由強迫勞工（現代奴隸）採摘的，你/妳仍然會買它嗎？
Would you still buy a tomato if you suspected it was picked by forced labor?



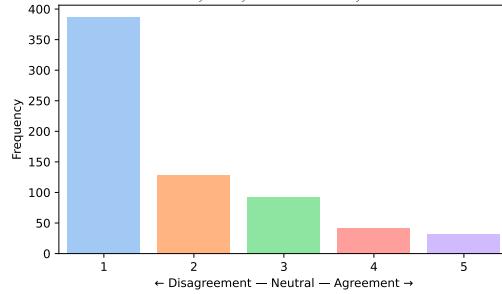
你/妳關心食安嗎？
Do you care about food safety?



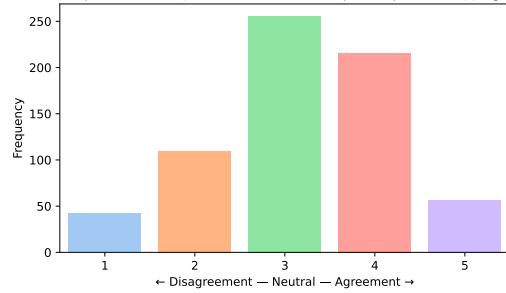
你/妳7年內買車嗎？
Will you buy a car within 7 years?



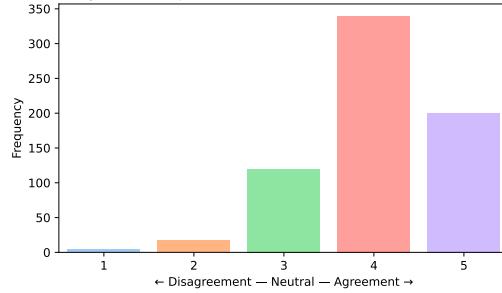
你/妳7年內買房嗎？
Will you buy a house within 7 years?



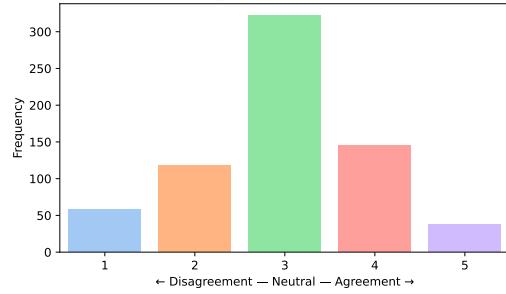
你/妳購物時知道產品環保嗎？
Do you know if the product is environmentally friendly when shopping?



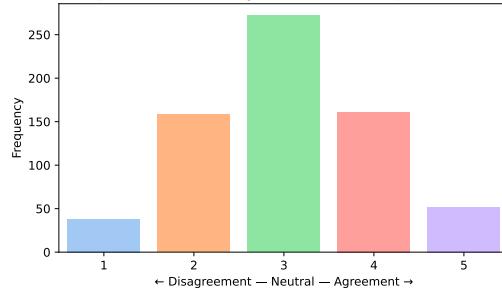
你/妳覺得認證環保的公司更好嗎？
Do you think companies with environmental certifications are better?



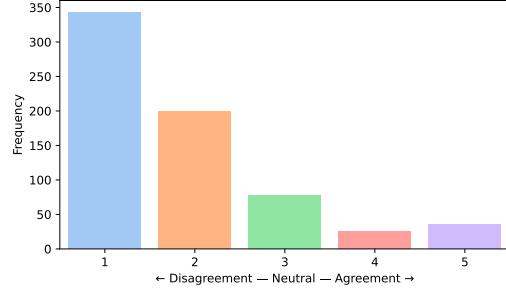
你/妳支持肉稅嗎？
Do you support a meat tax?



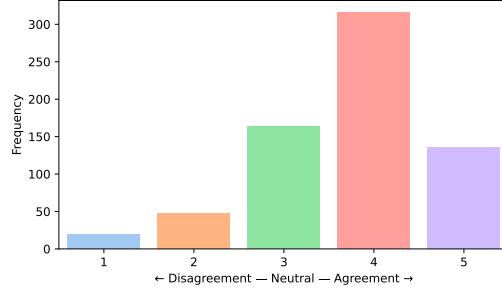
你/妳關心食用雞的生活嗎？
Do you care about the living conditions of chickens you consume?



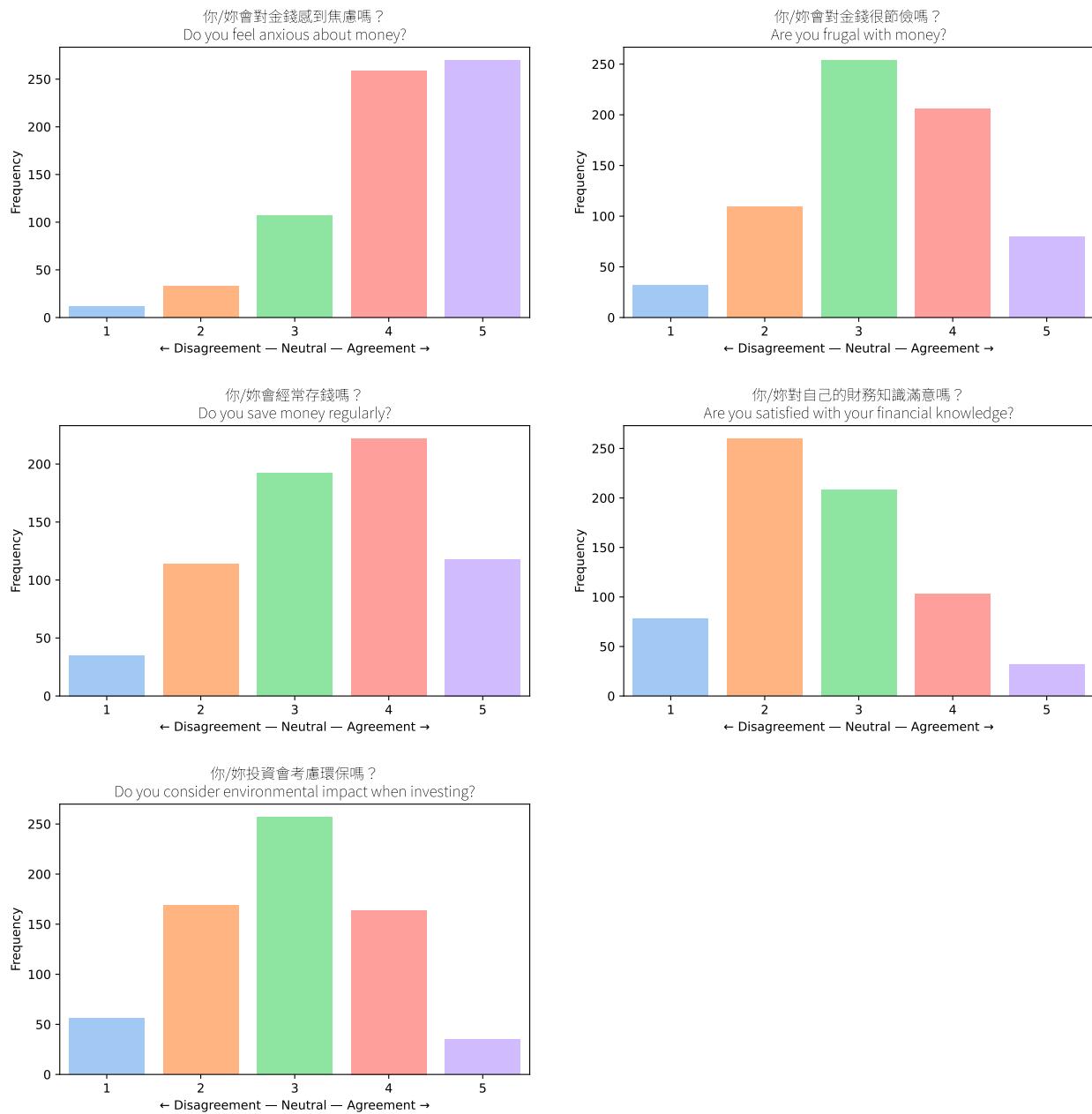
你/妳避免吃肉嗎？
Do you avoid eating meat?



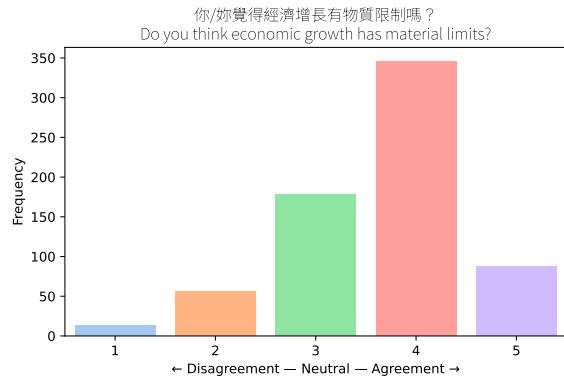
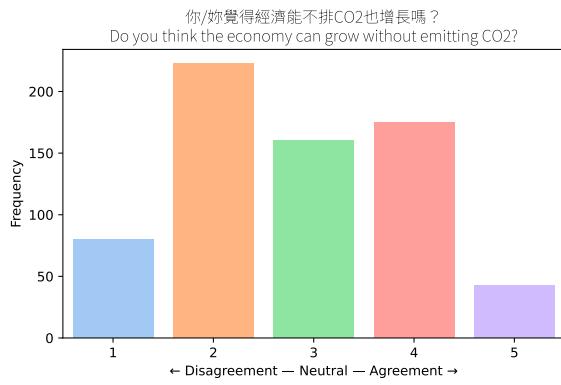
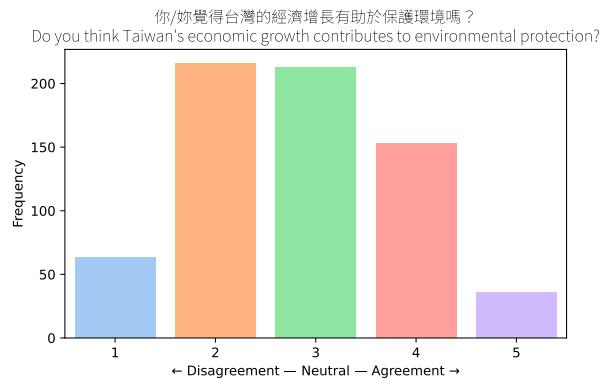
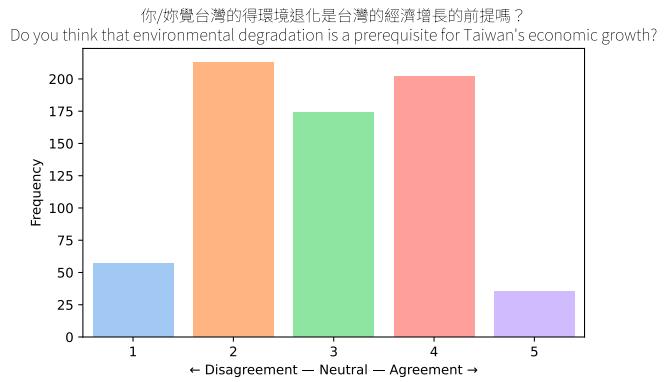
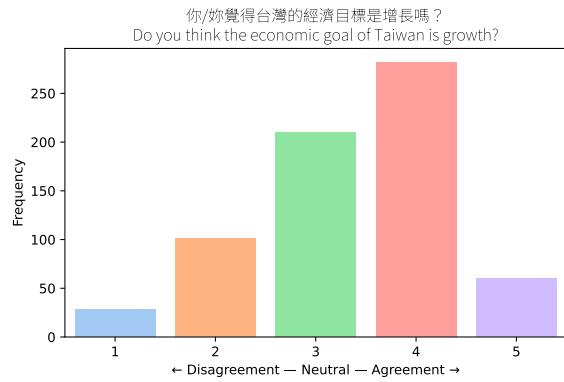
你/妳覺得你/妳花錢會影響環境嗎？
Do you think your spending affects the environment?



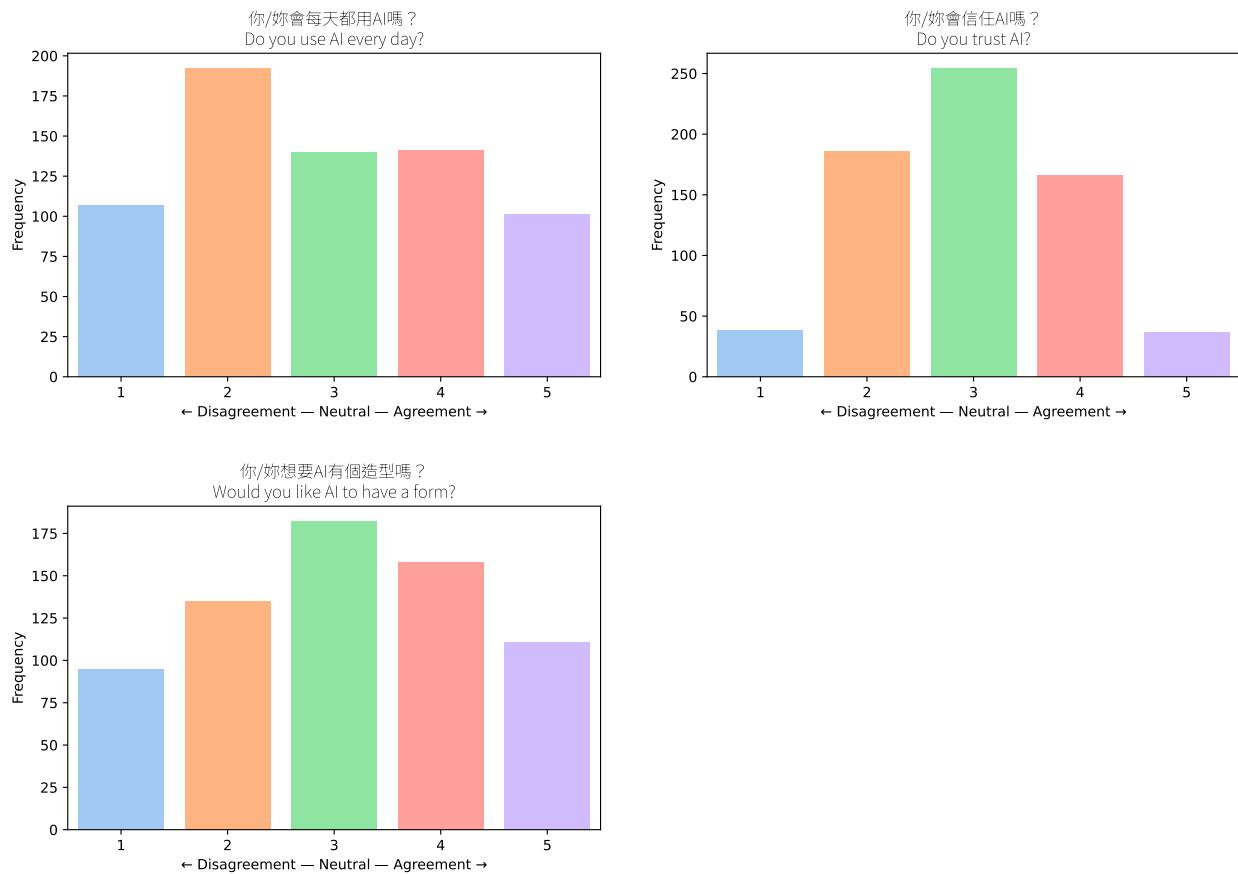
Saving and Investing



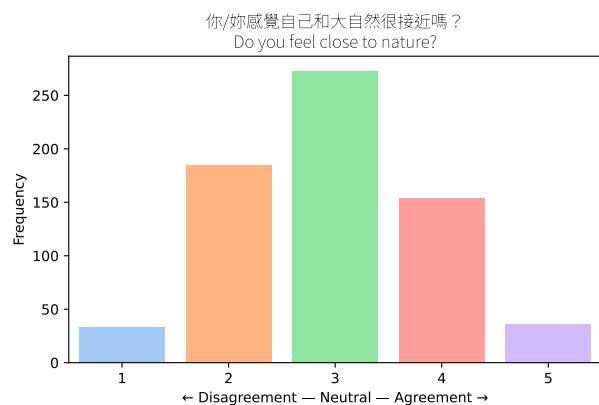
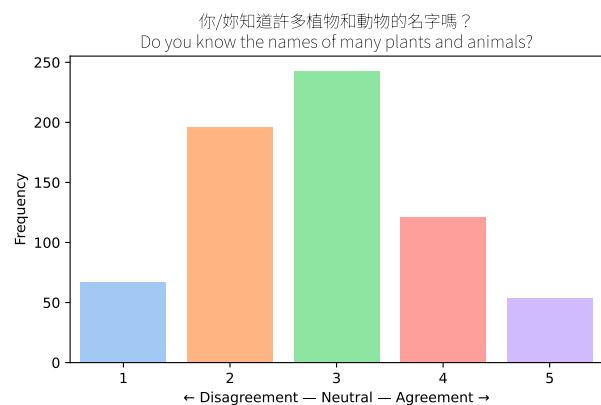
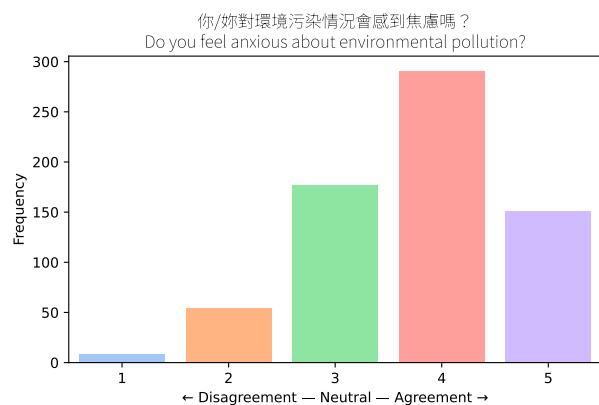
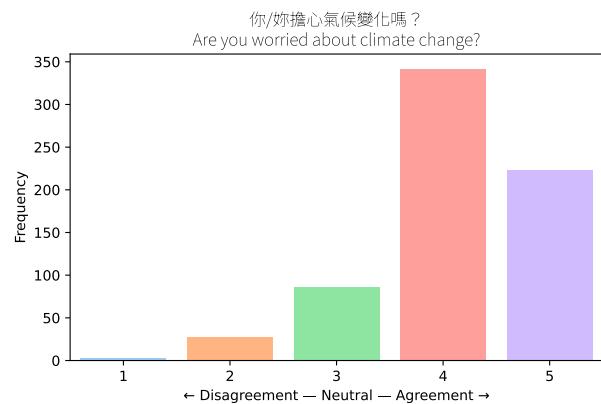
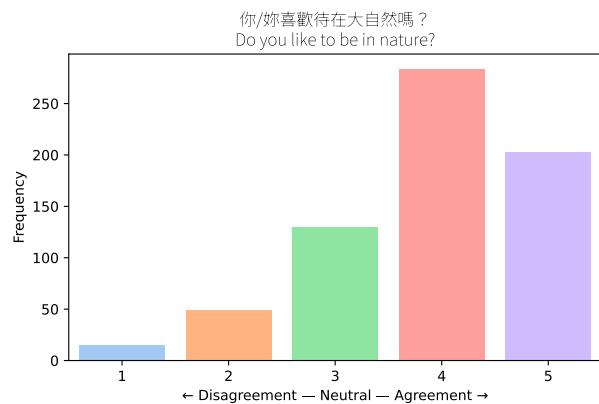
Economy



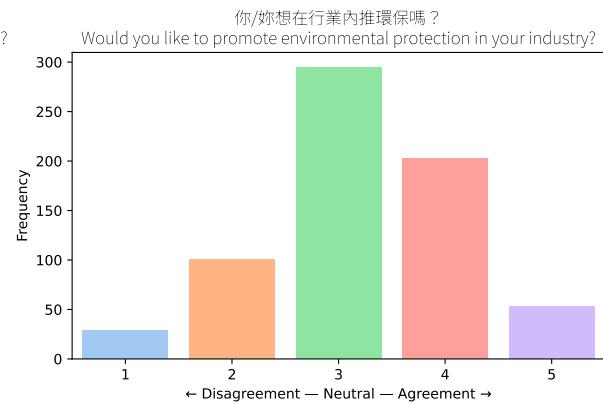
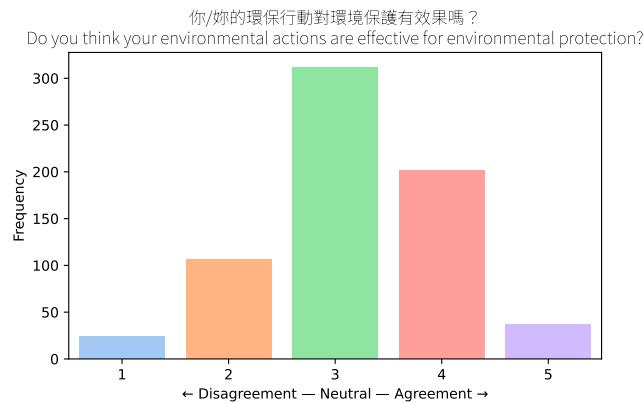
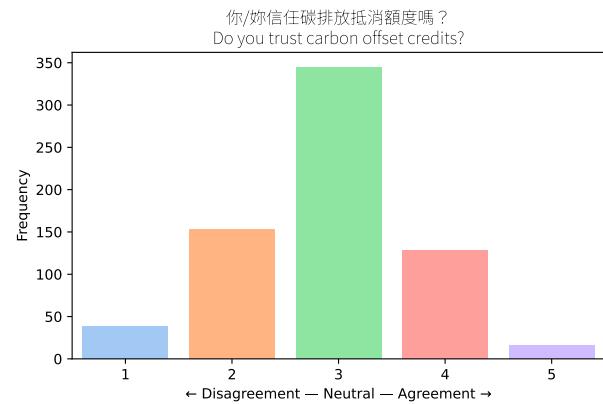
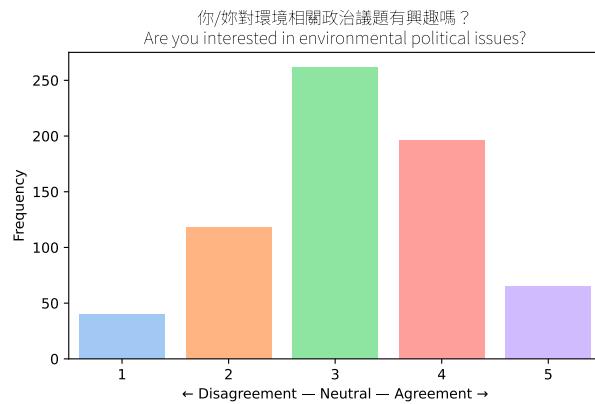
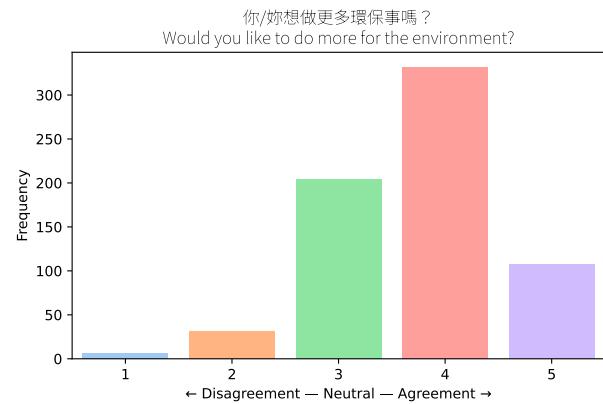
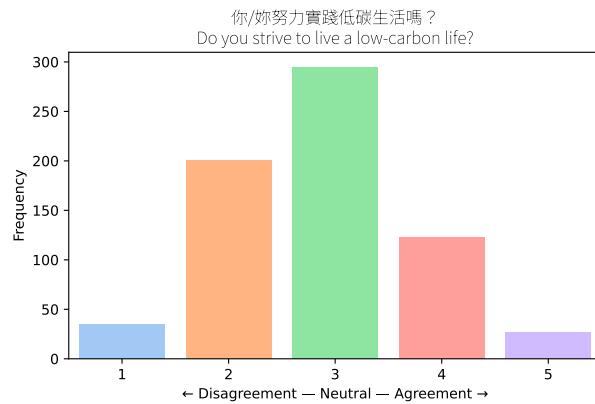
AI Usage



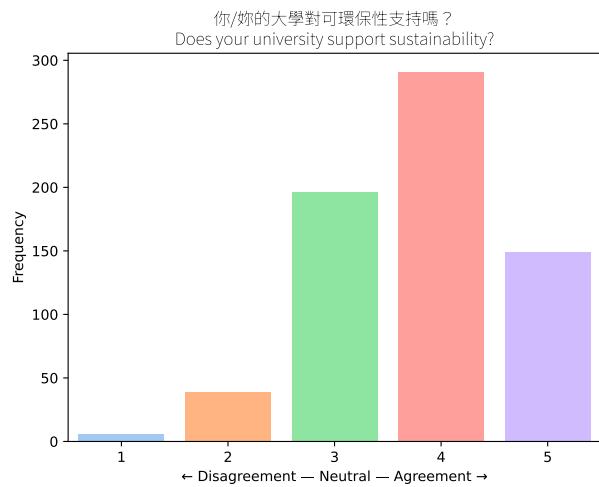
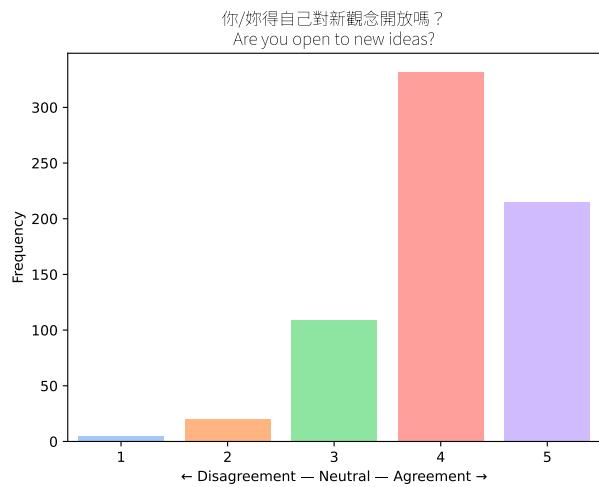
Nature



Environmental Protection

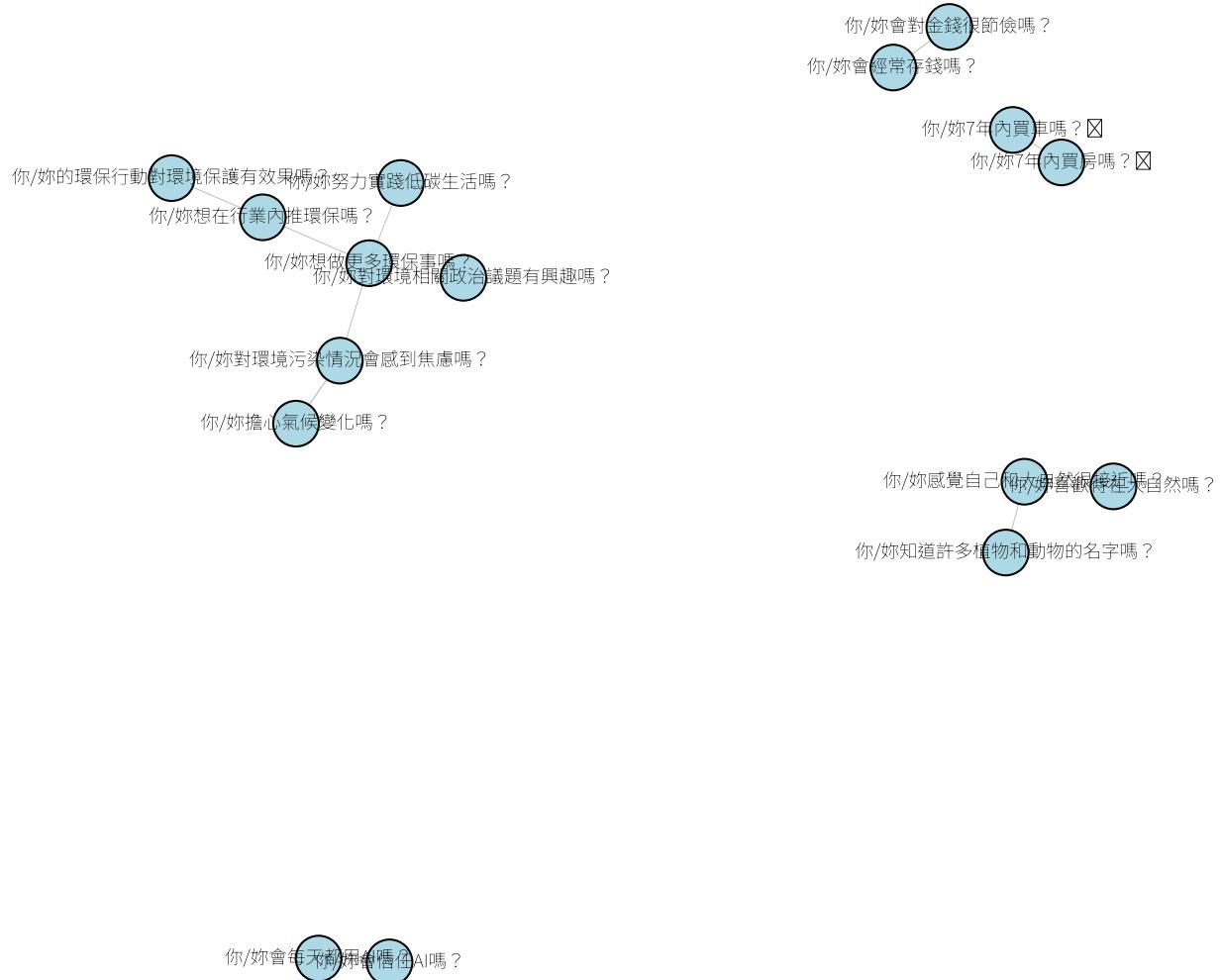


Learning Environment



Correlations Between Fields

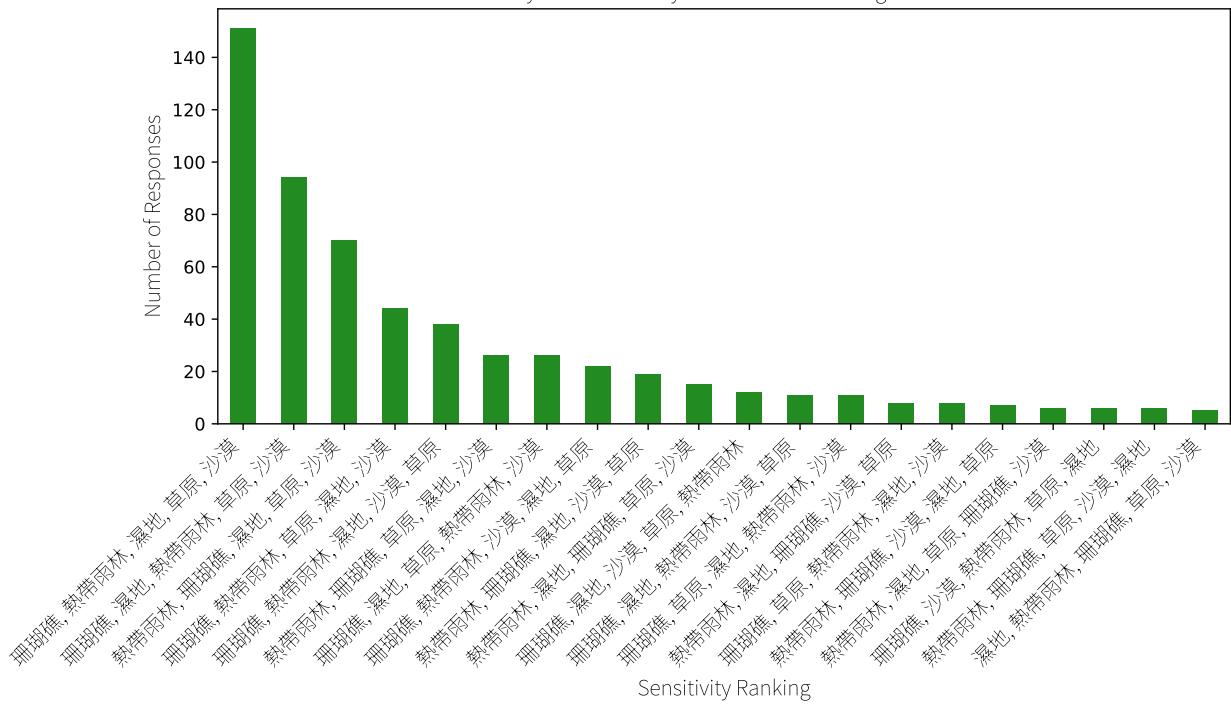
Correlation Network



Environmental Knowledge Ranking Experiment

Test knowledge about the environment.

Ecosystem Sensitivity to Environmental Degradation

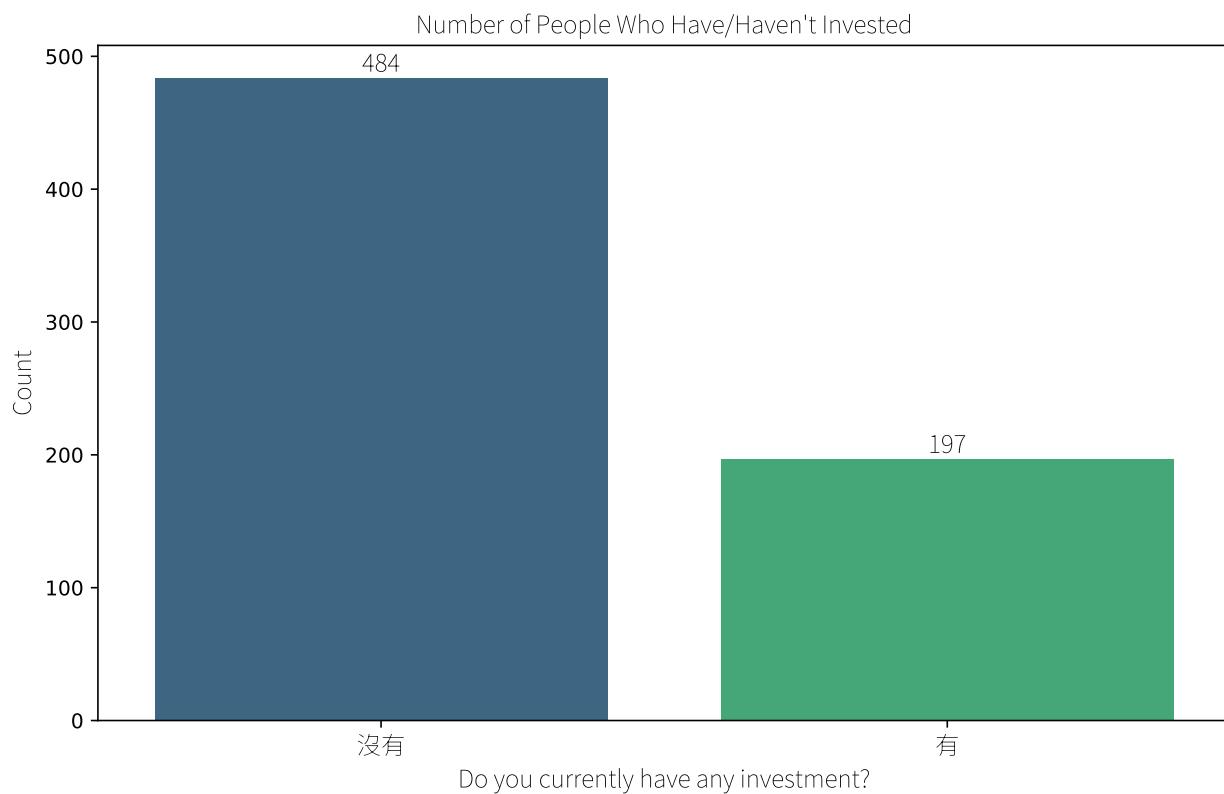


Design implication: majority don't plan to buy a house or car within 7 years, don't focus on these categories. Majority don't fly much, don't focus on flights.

Investing

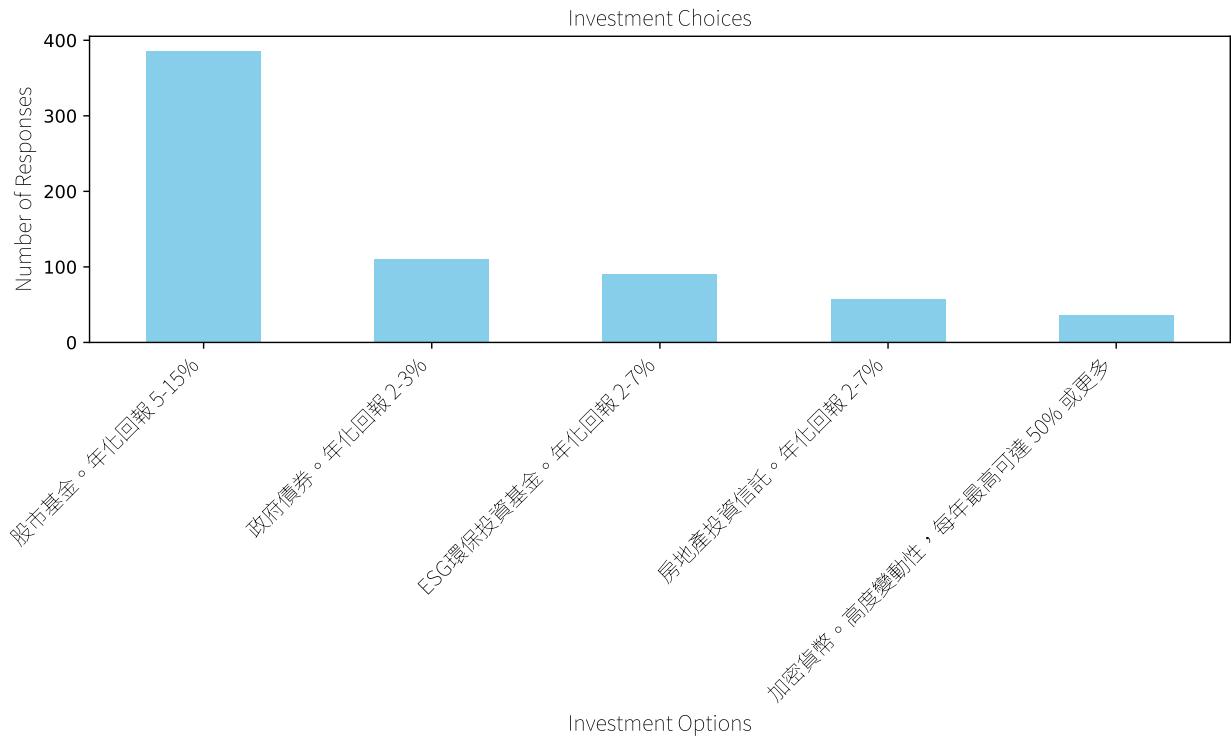
Student attitudes towards investing.

Investing Experience (Overall)



Choice Experiment

Question: 你/妳選哪個投資? Which investment do you choose?



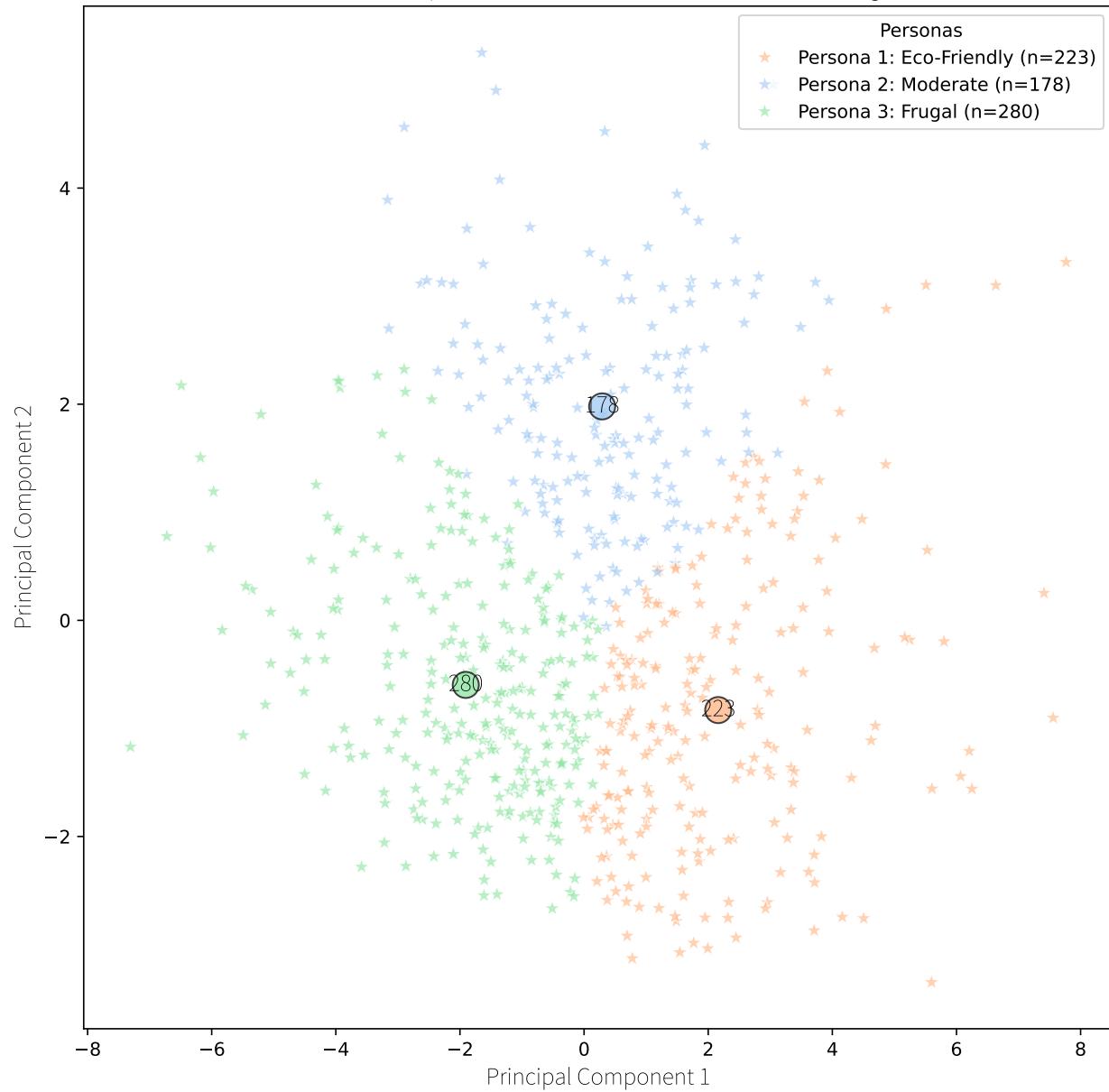
Personas

Clustering Students to Build 3 Personas

Personas are created using K-means clustering, an unsupervised machine learning algorithm, which clusters college students based on their responses across 36 Likert-scale fields in the online survey. Clusters are visualized using Principal Component Analysis (PCA), where the principal component loadings on the X and Y axes represent the weights of the original Likert-scale fields, transformed into the principal components that capture the most variance.

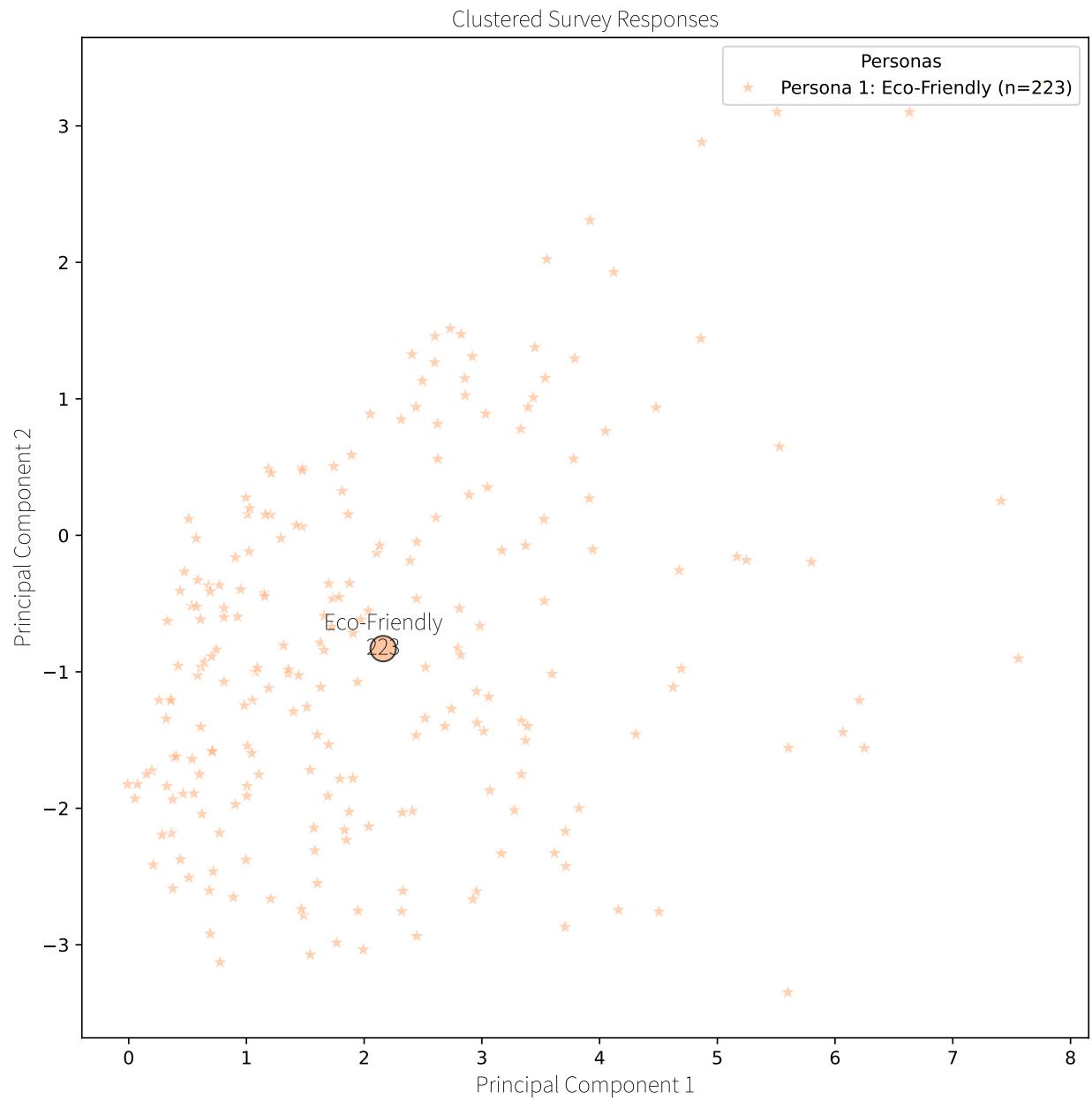
- There is some similarity between clusters. All 3 personas report a high level of financial anxiety and below-average satisfaction with their financial literacy.
- Principal Component Analysis (PCA) is used to convert data to lower dimension space. This is a predecessor of embeddings.

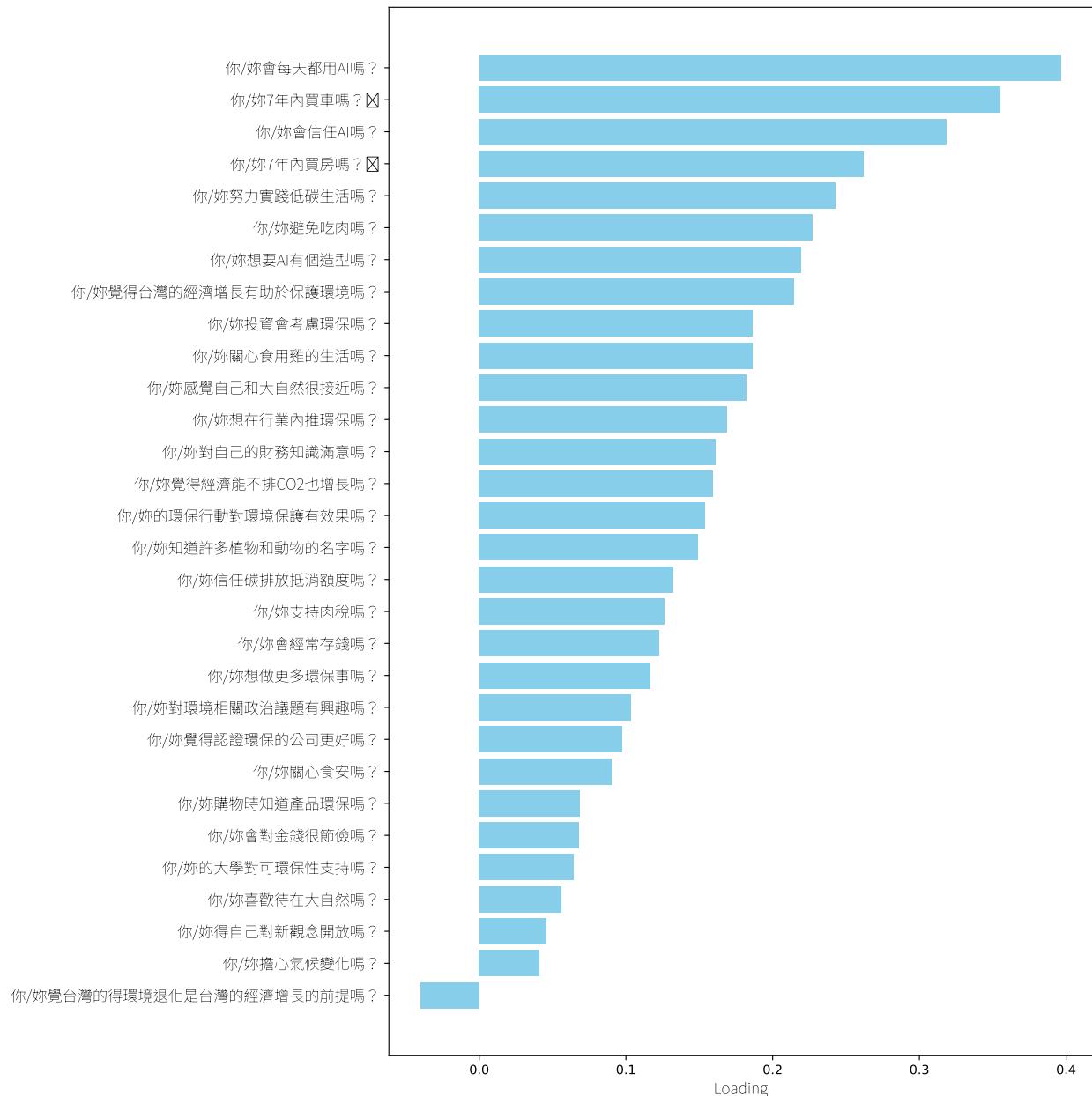
Distinct Respondent Profiles Based on K-means Clustering

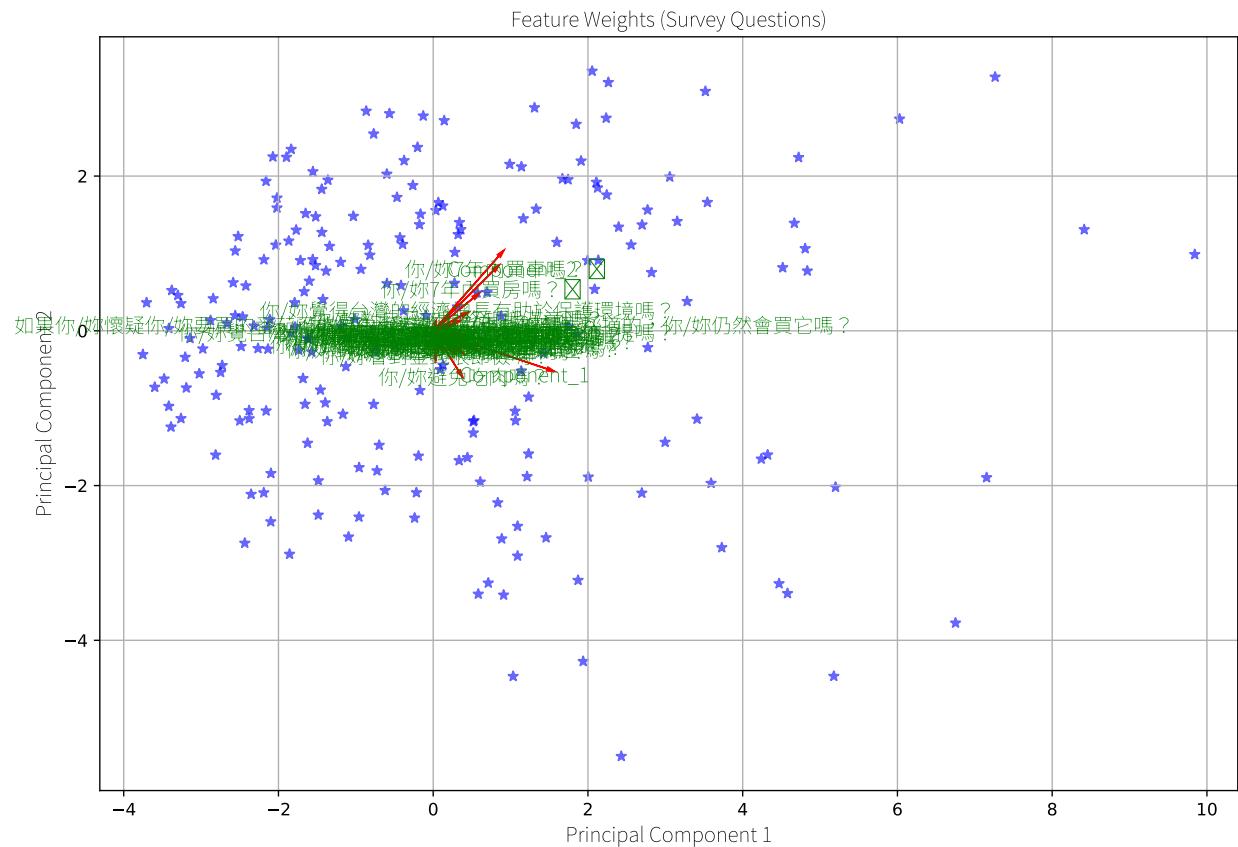


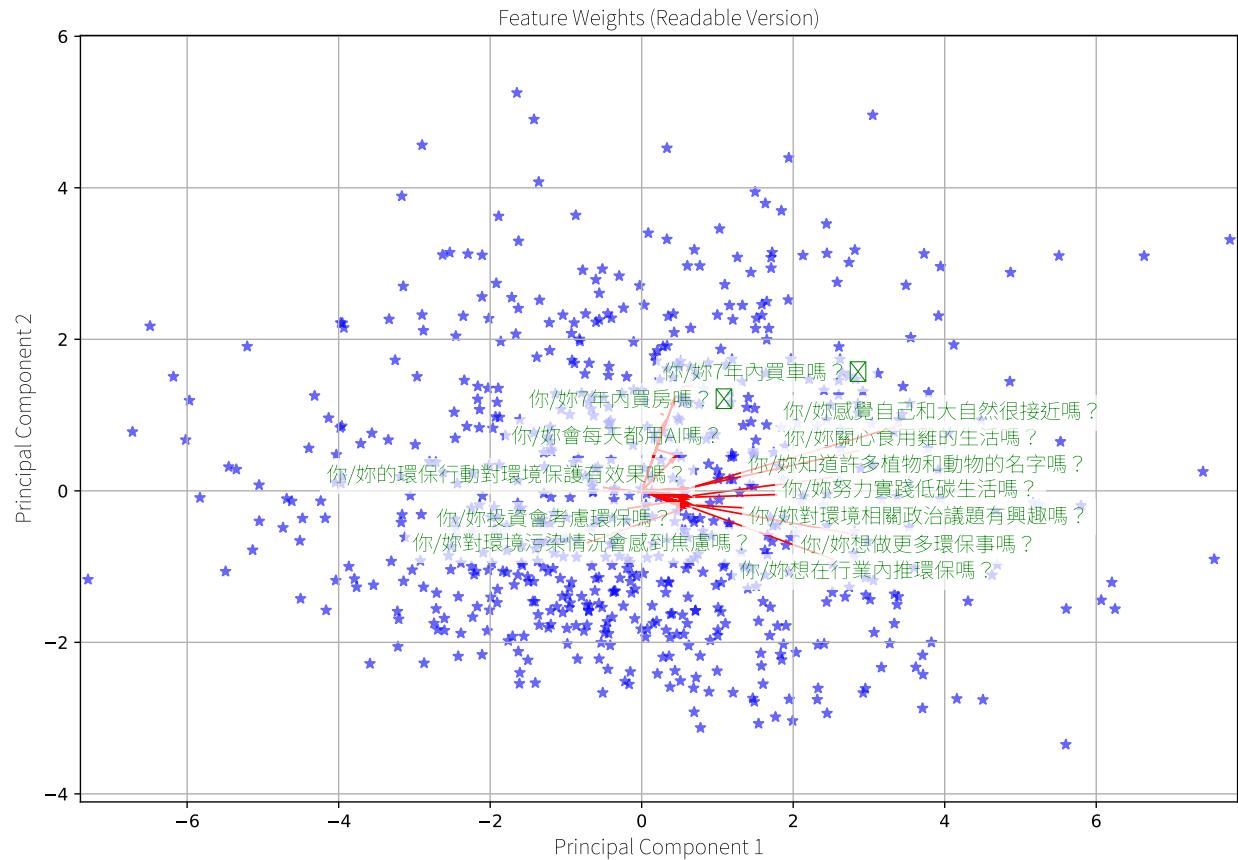
Persona 1: “Eco-Friendly”

Questions Most Affecting Persona Creation include...



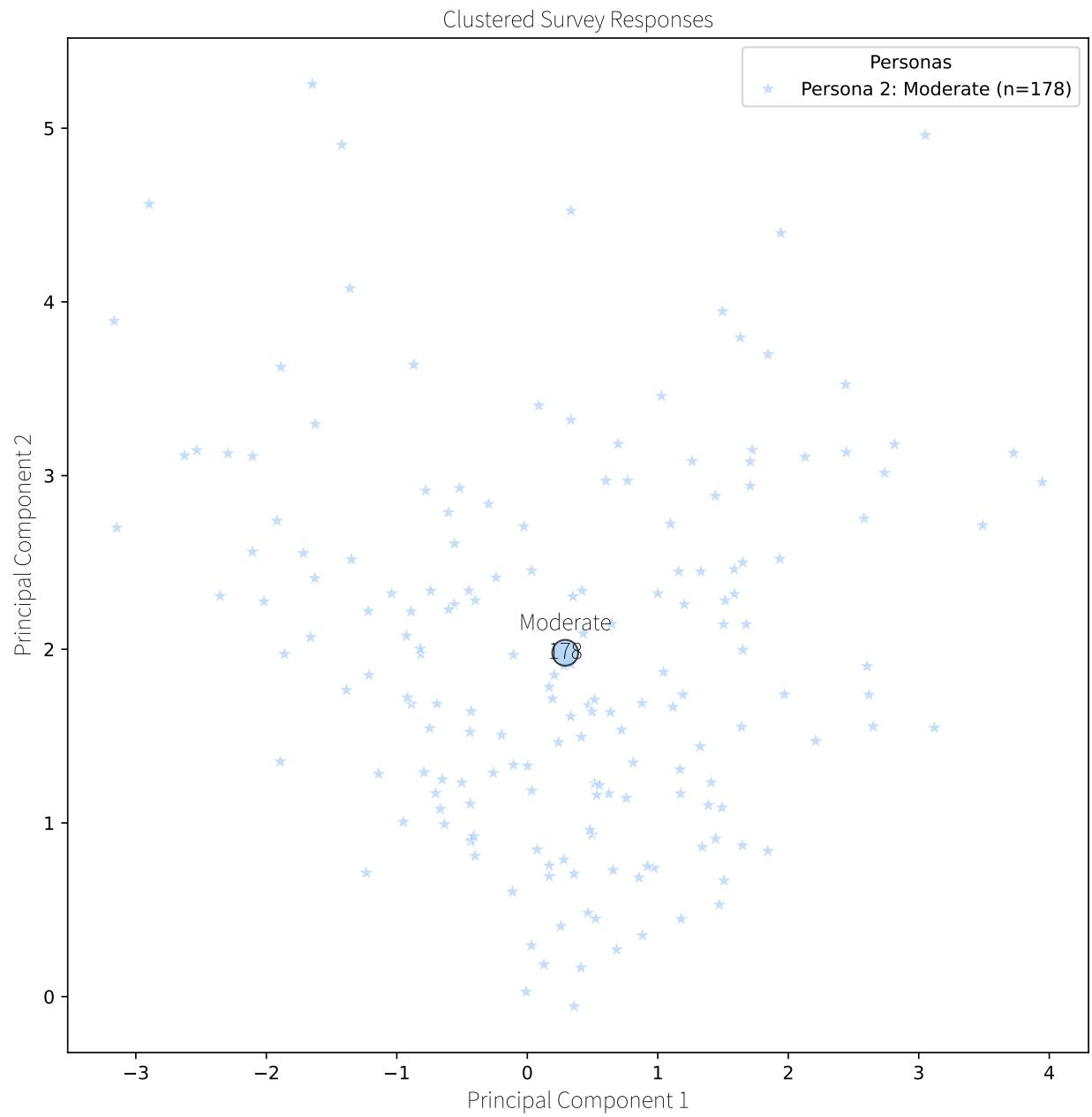


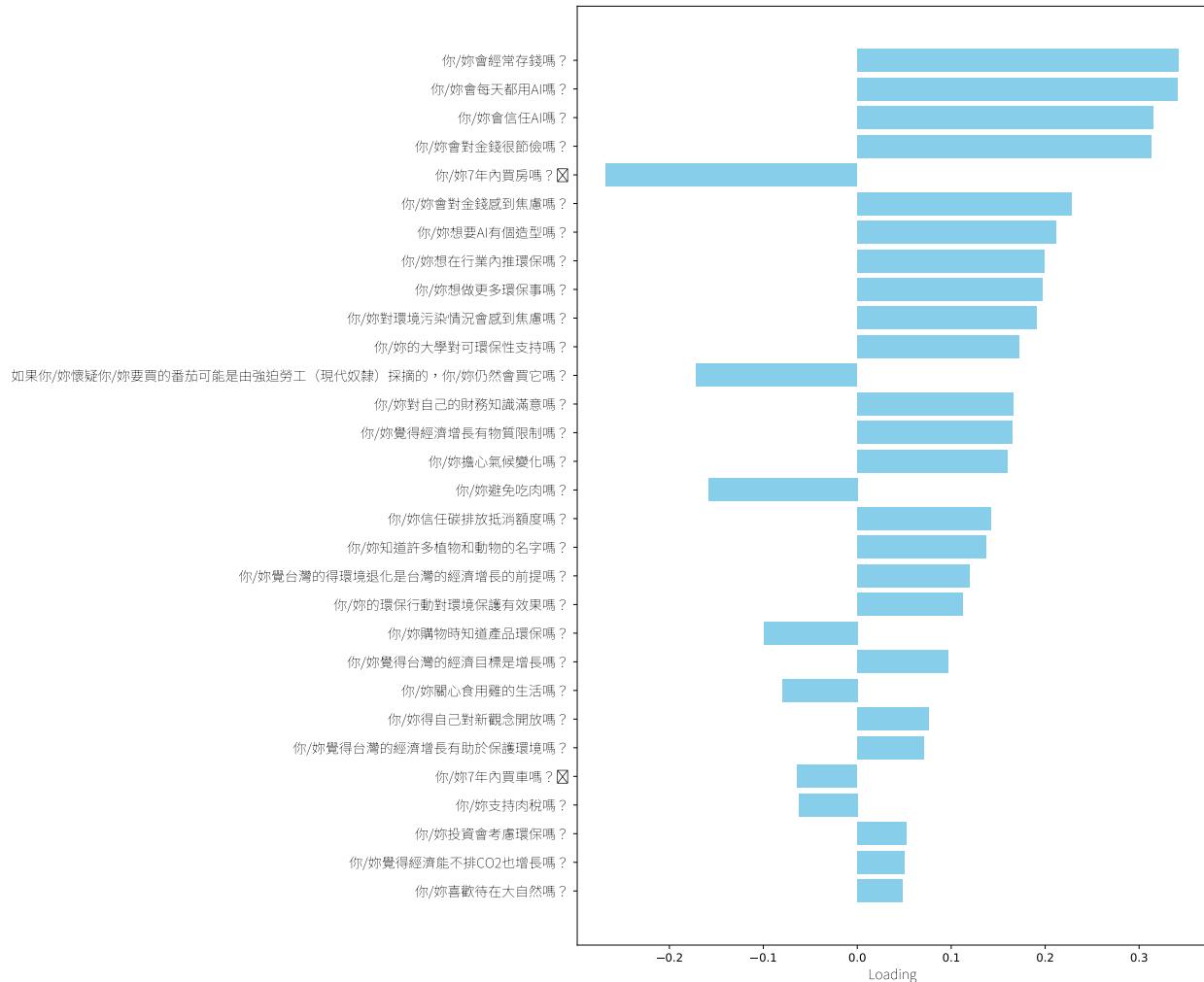


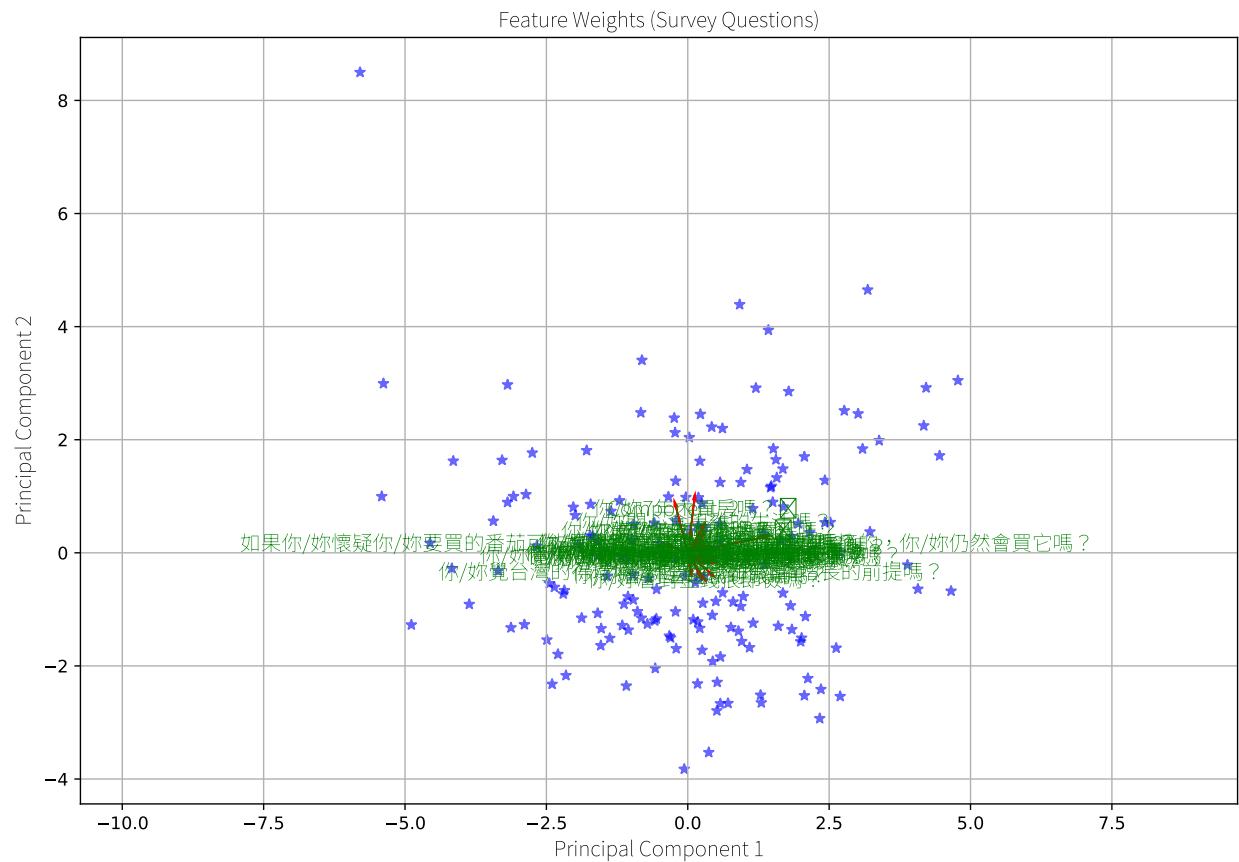


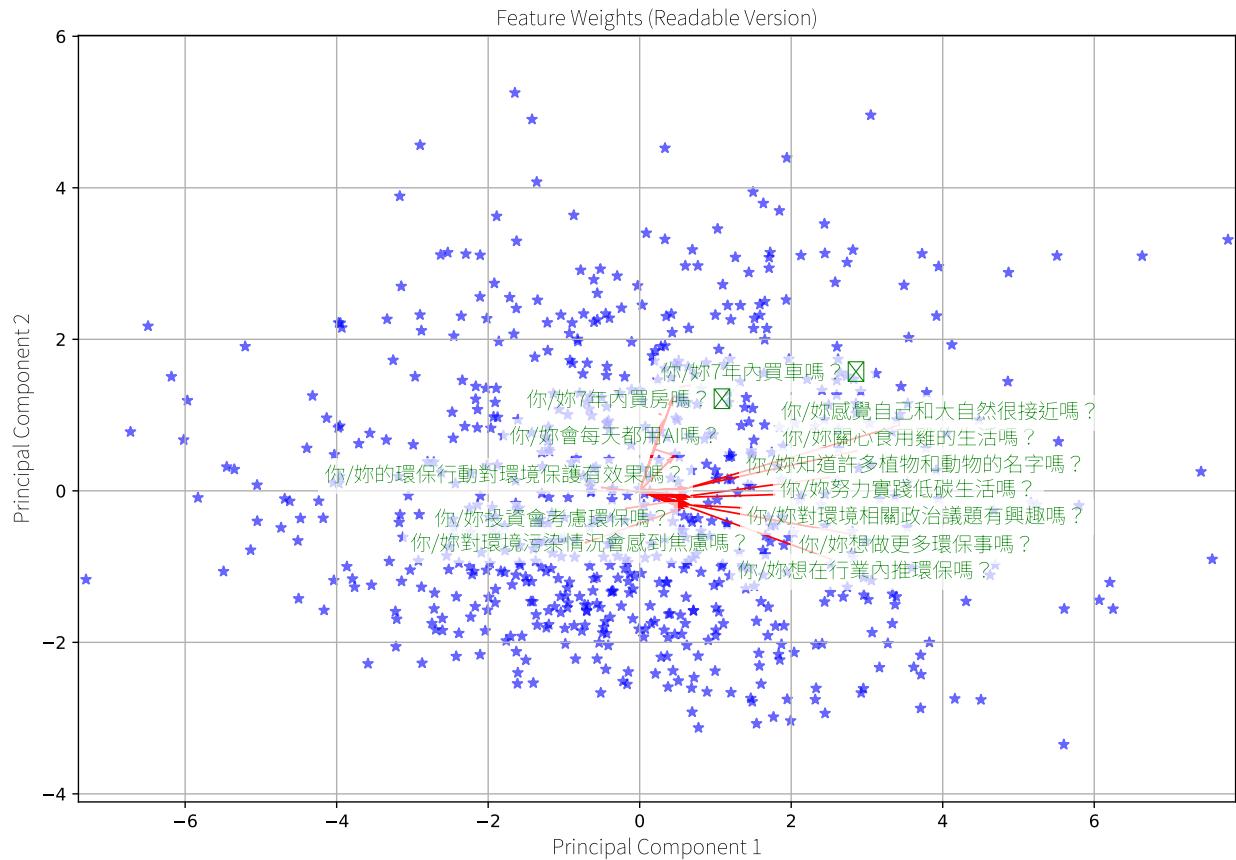
Persona 2: “Moderate”

Questions Most Affecting Persona Creation include...





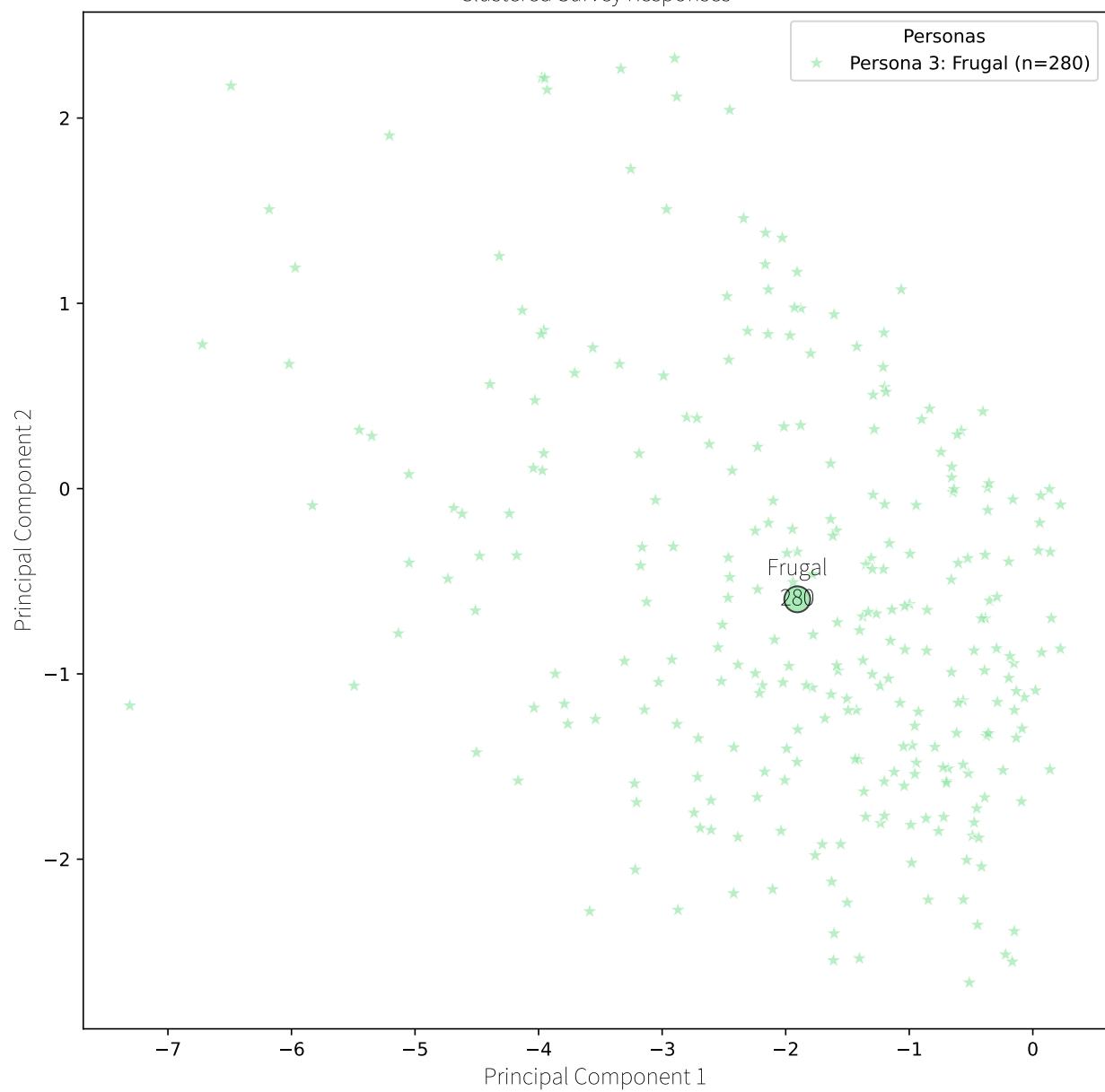


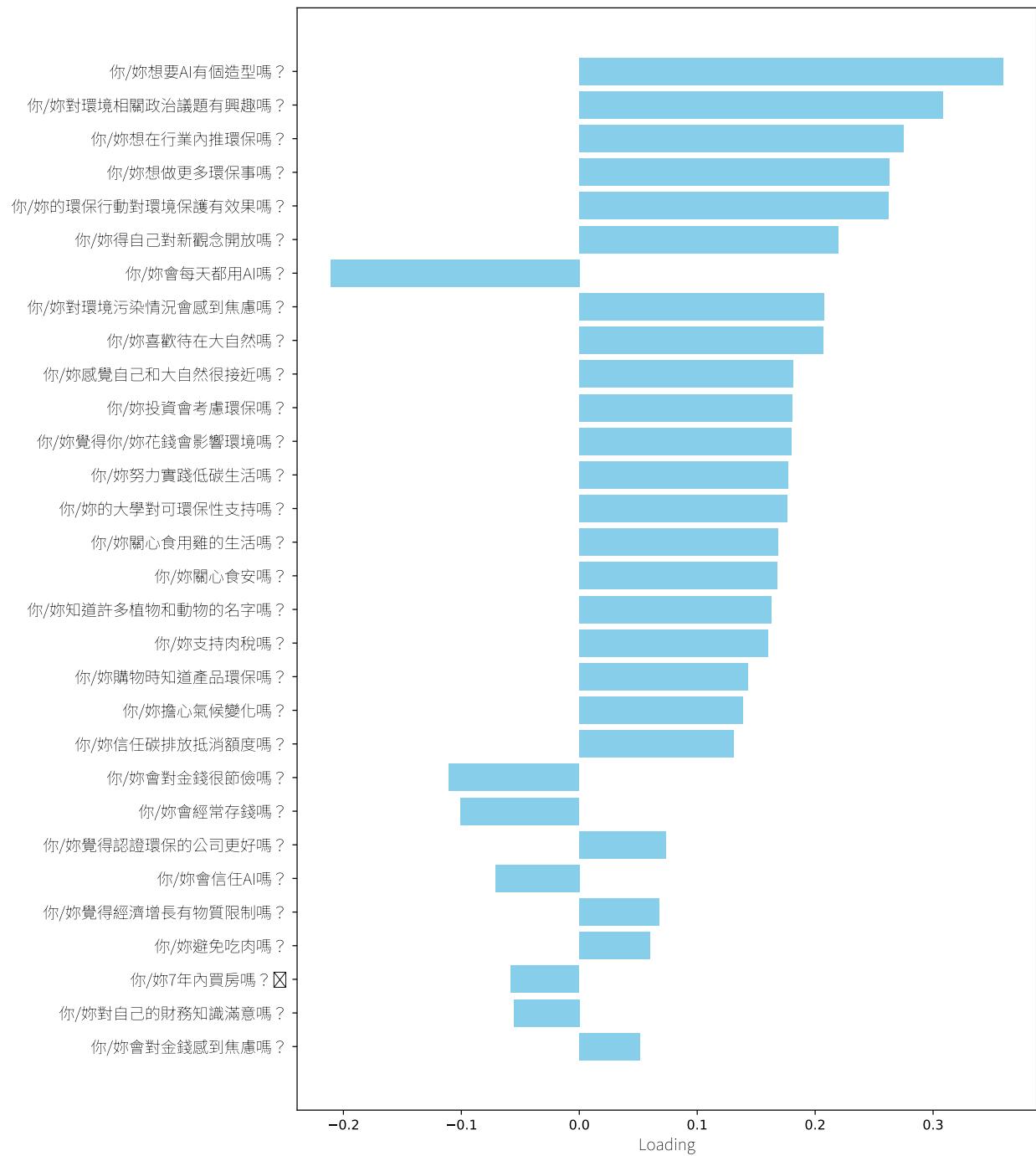


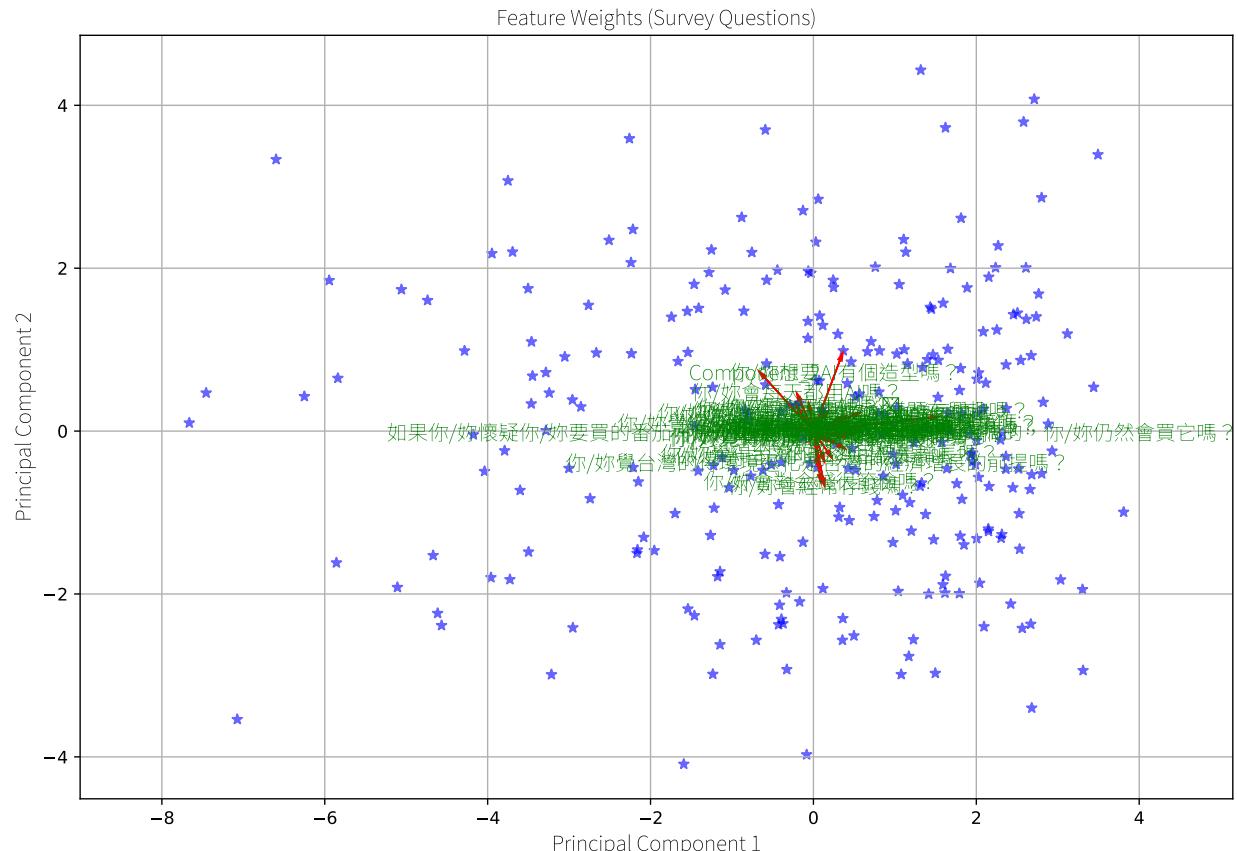
Persona 3: “Frugal”

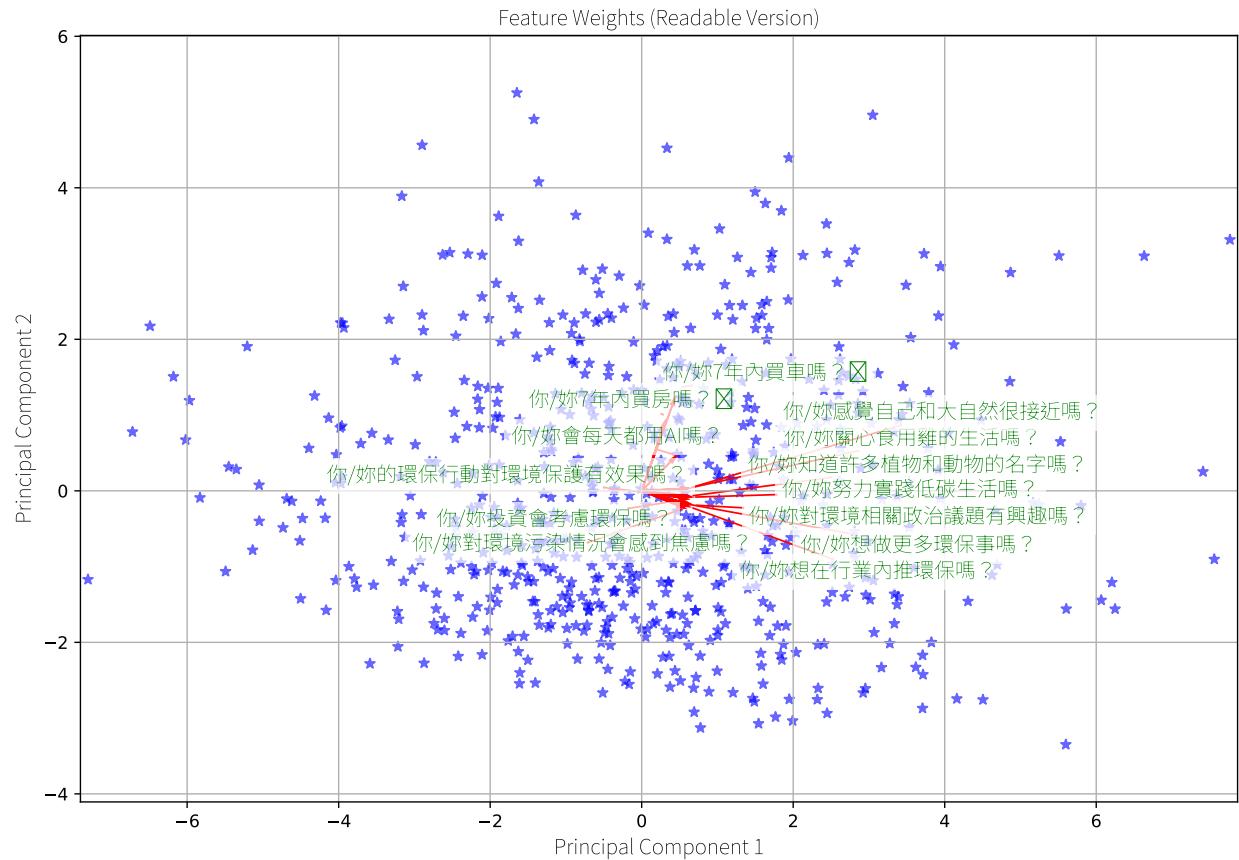
Questions Most Affecting Persona Creation include...

Clustered Survey Responses

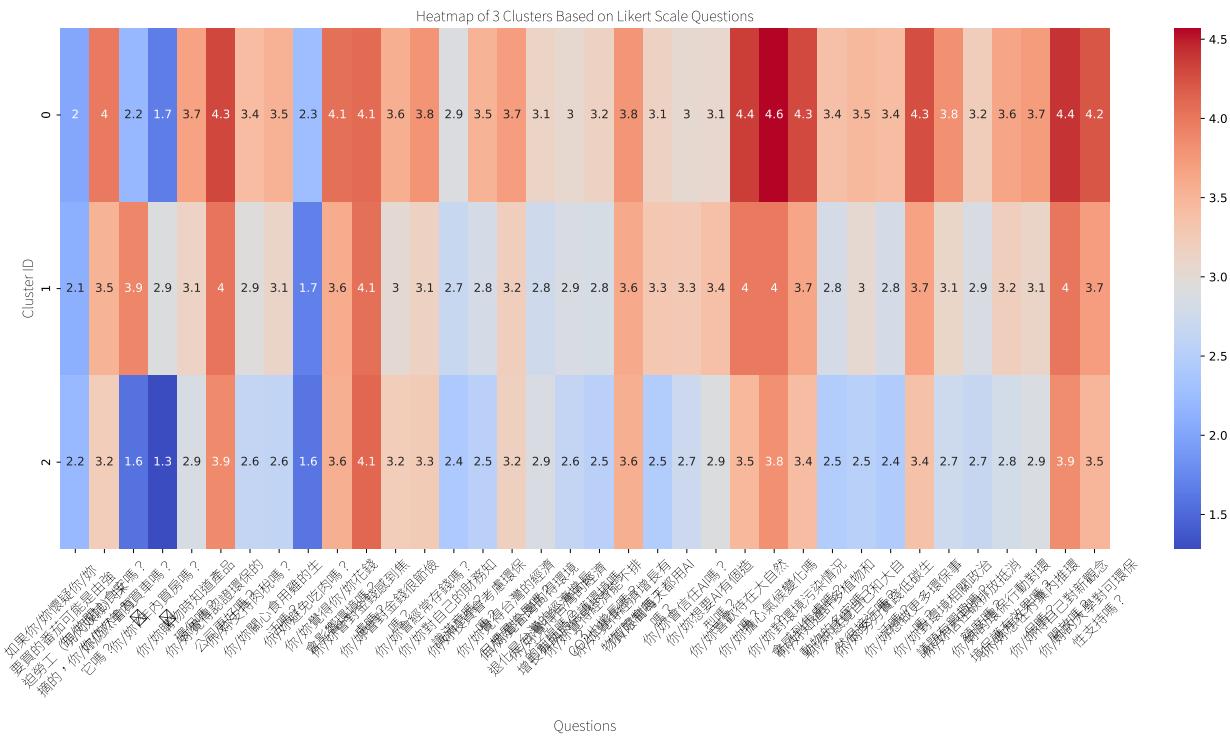








Clustering Heatmap



Mean Answer Scores

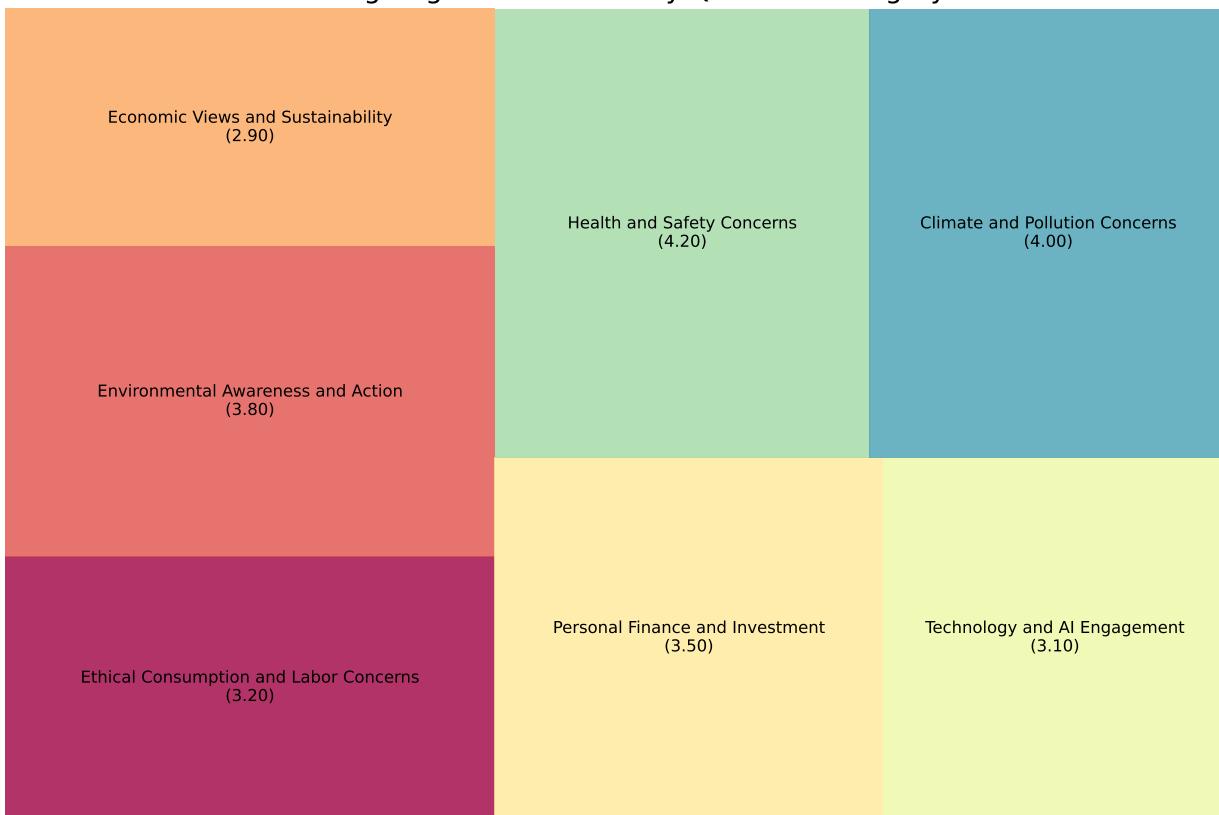
Mean response values for each Likert question in each cluster:

Cluster	如果你/妳懷疑你/妳要買的番茄可能是由強迫勞工（現代奴隸）採摘的，你/妳仍然會買它嗎？	你/妳願意付多少錢？
0 0	2.026906	3.99103
1 1	2.106742	3.51683
2 2	2.214286	3.22500

Agreement between personas

Highest agreement between personas is about health, safety, pollution and climate concerns.

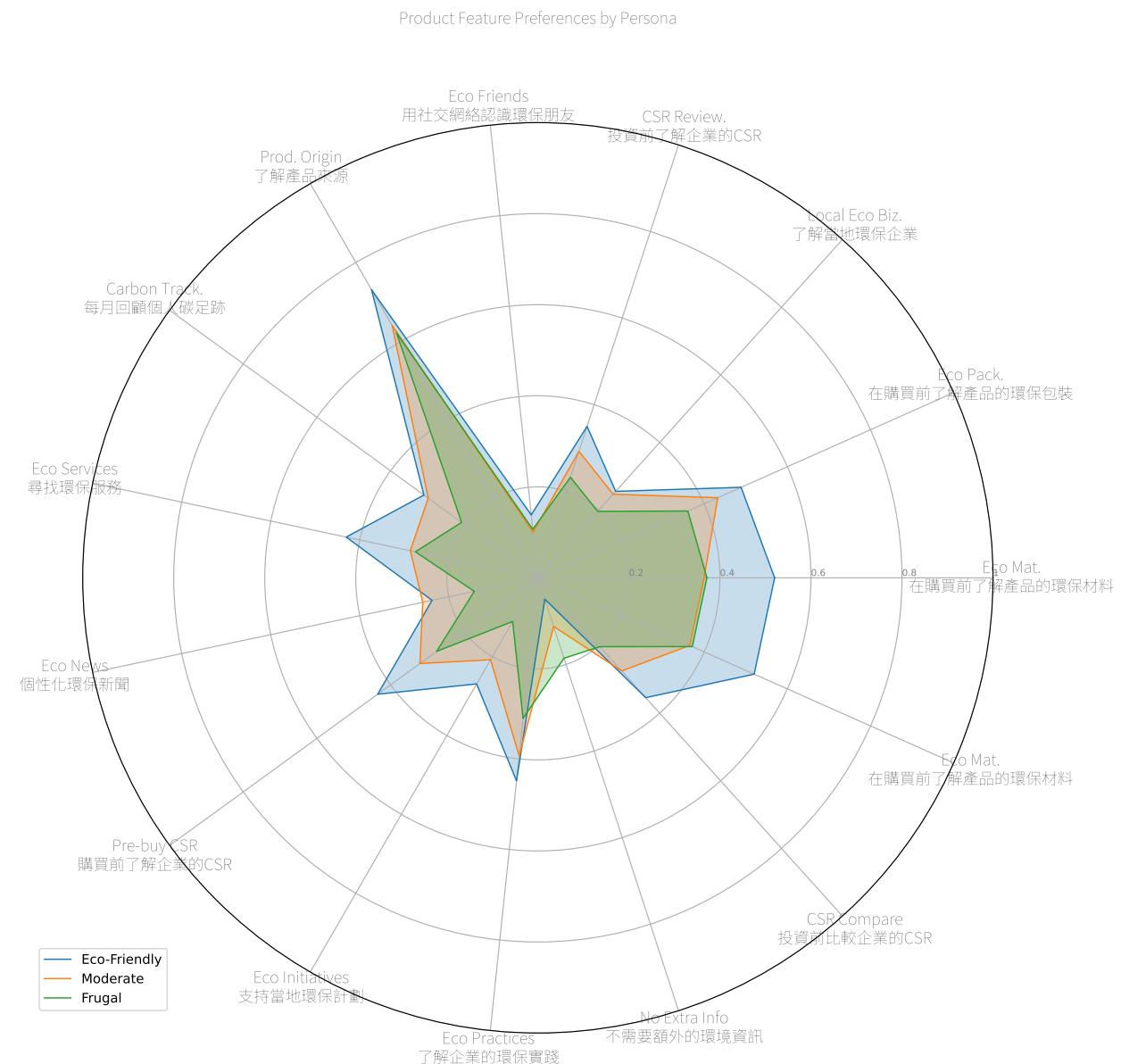
Average Agreement Level by Question Category



AI Companion

Likert-Based Clustering

AI-assistant feature choices per Likert-based Personas



Want: - Product origin - Product materials - Product packaging

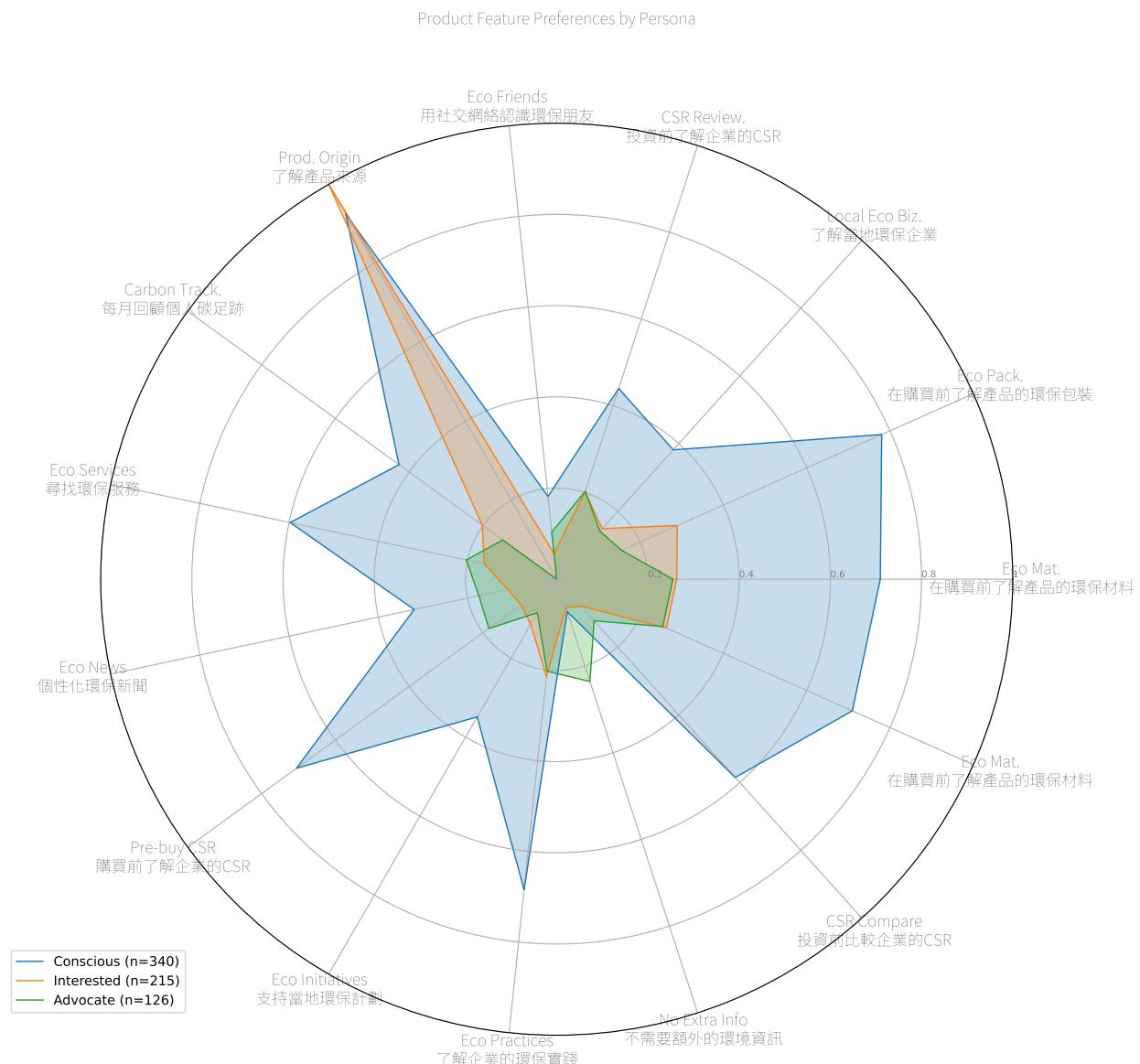
Don't Want: - News - Carbon tracking - Eco-friends - ...

Feature-Based Clustering

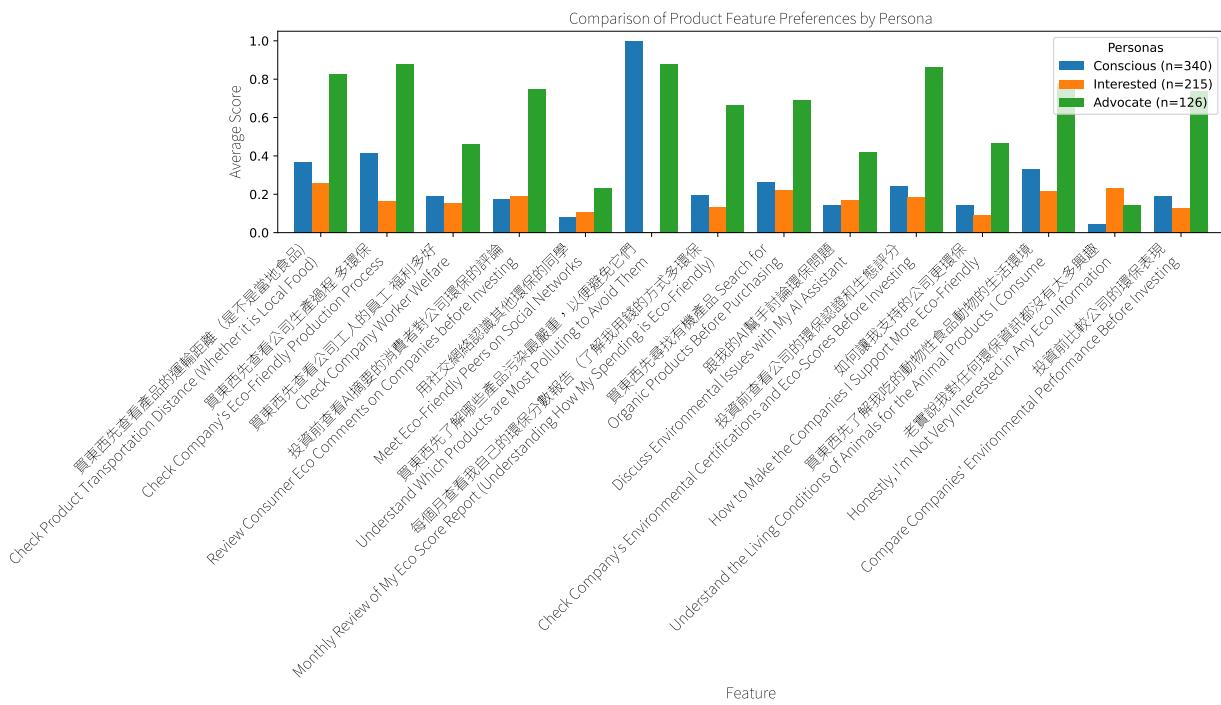
Clustering students based on AI-assistant feature choices.

Want: - Product origin - Product materials - Product packaging - Eco services

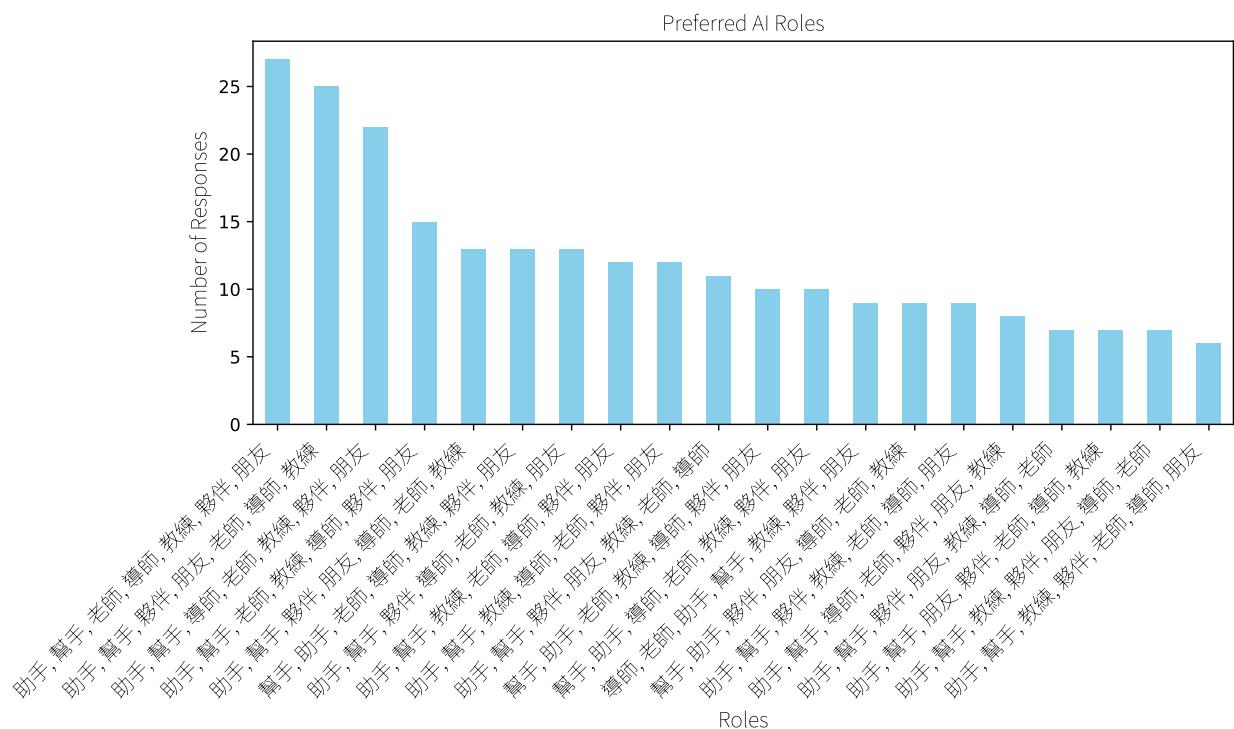
Feature Preferences (Overall)



Feature Preferences (By Cluster)



Preferred AI Roles (Overall)



Experts

Analysis of recorded conversation from 5 experts. Thematic content analysis using ATLAS.ti for labeling/coding the data for grounded theory. Conversations were recorded and transcribed using Google Meet and Fireflies AI. Labeling and thematic analysis was performed using Atlas.ti. Visualisations were produced using Atlas.ti and Python.

Interview 1: Designer - Cathy Wang

Date: 2023-11-10 Expert: Cathy Wang is a designer and business leader with 20 years of experience in bringing hypergrowth and hundreds of millions of EUR in revenue in digital transformation of industry. Country: Taiwan / Canada Topics: Design, Business

Thematic Analysis.

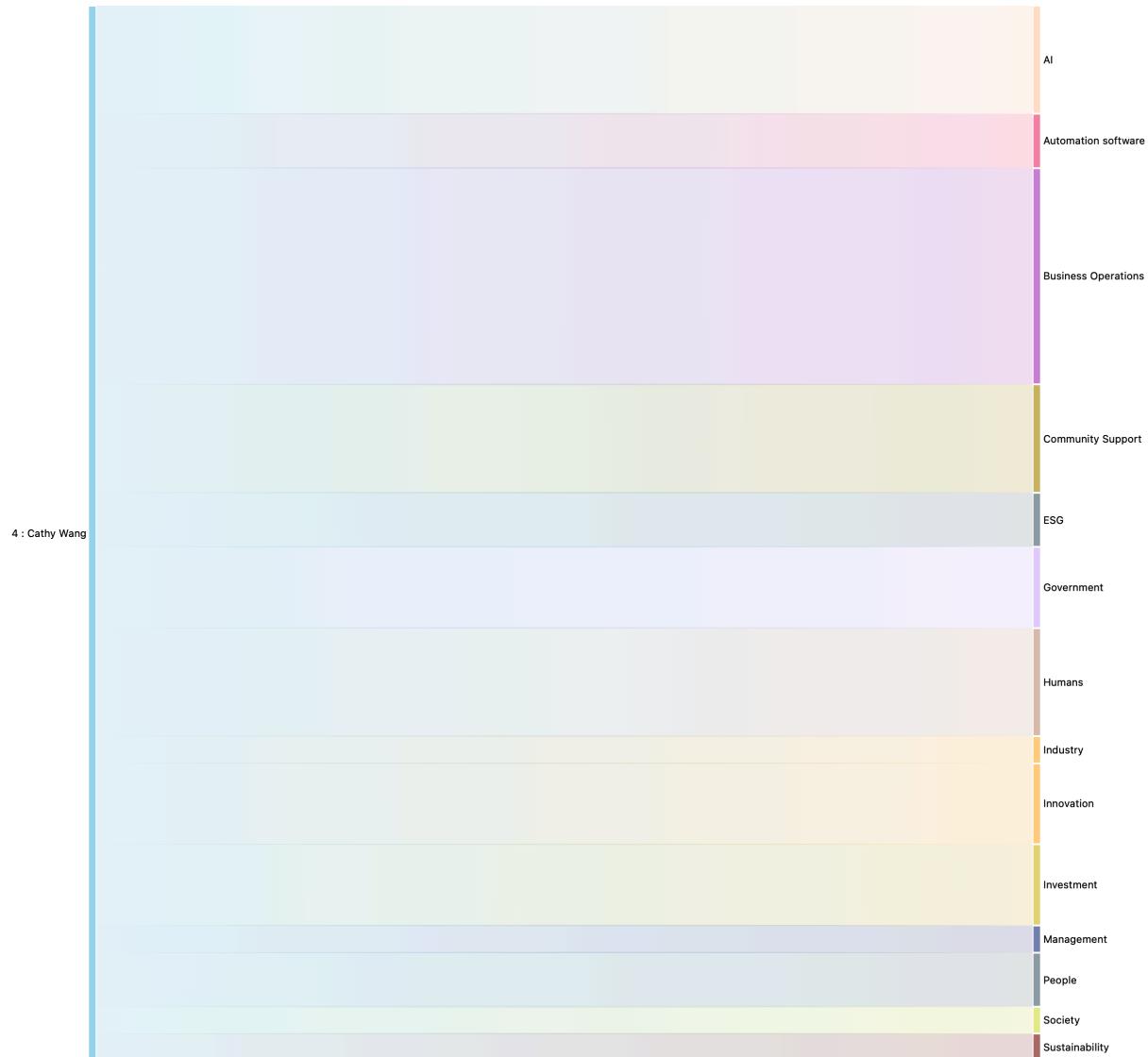


Figure 14: Cathy Wang

Interview 2: Accountant - Peijing Li

Date: 2023-11-18 Expert: Peijing Li is an accomplished financial controller and accountant with experience in varied industries from dairy to education. Country: New Zealand Topics: Economics

Thematic Analysis.



Figure 15: Peijing Li

Interview 3: Designer - Jessica Cheng

Date: 2023-12-04 Expert: Jessica Cheng is a designer with cross-industry experience from the UK and Taiwan. Country: Taiwan Topics: Design, Business

Thematic Analysis.

5 : Jessica Cheng

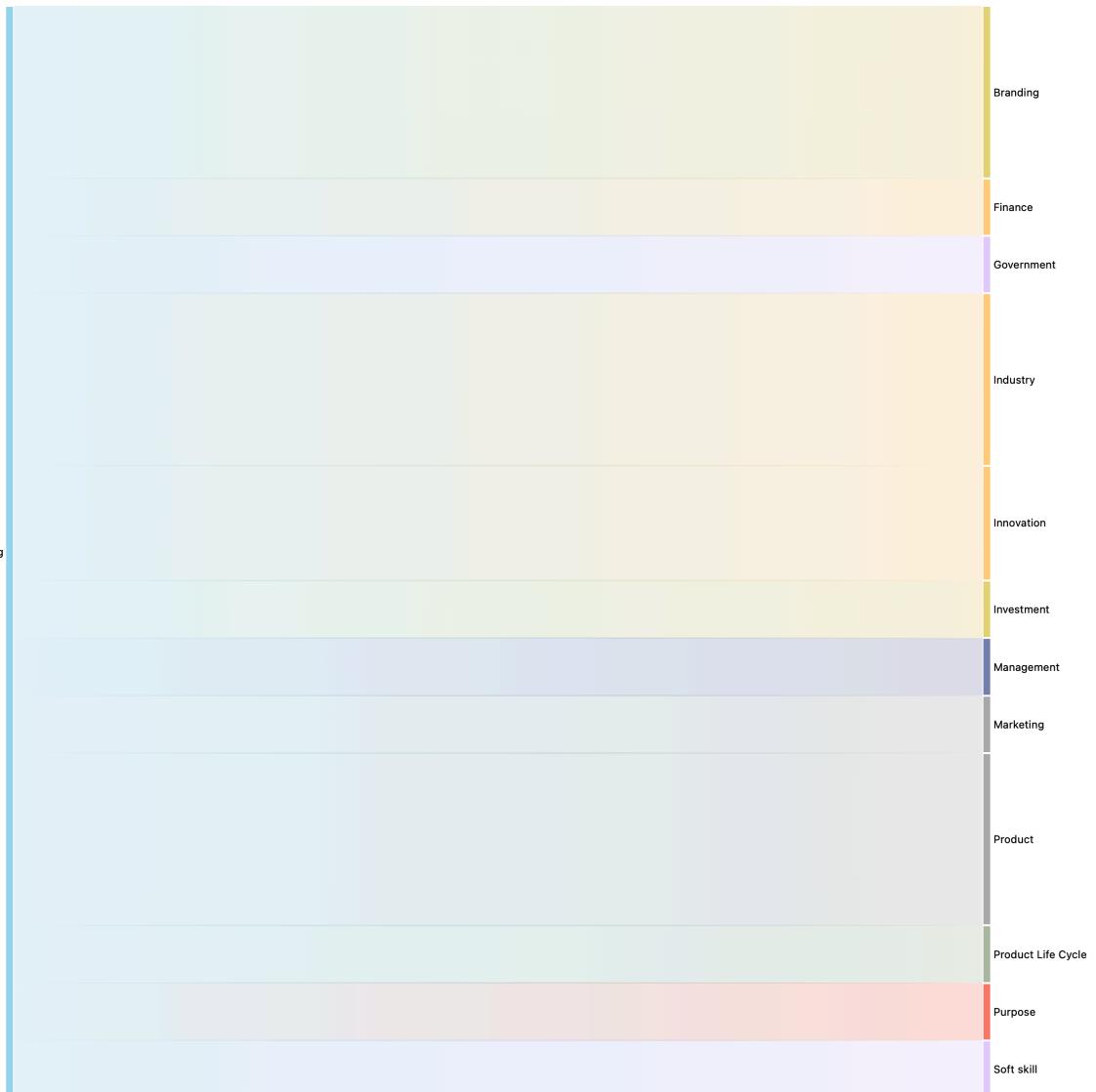


Figure 16: Jessica Cheng

Interview 4: Economist - Chen-Ying Huang

Date: 2024-05-19 Expert: Chen-Ying Huang is an economist and professor at National Taiwan University. Country: Taiwan Topics: Economics

Thematic Analysis.

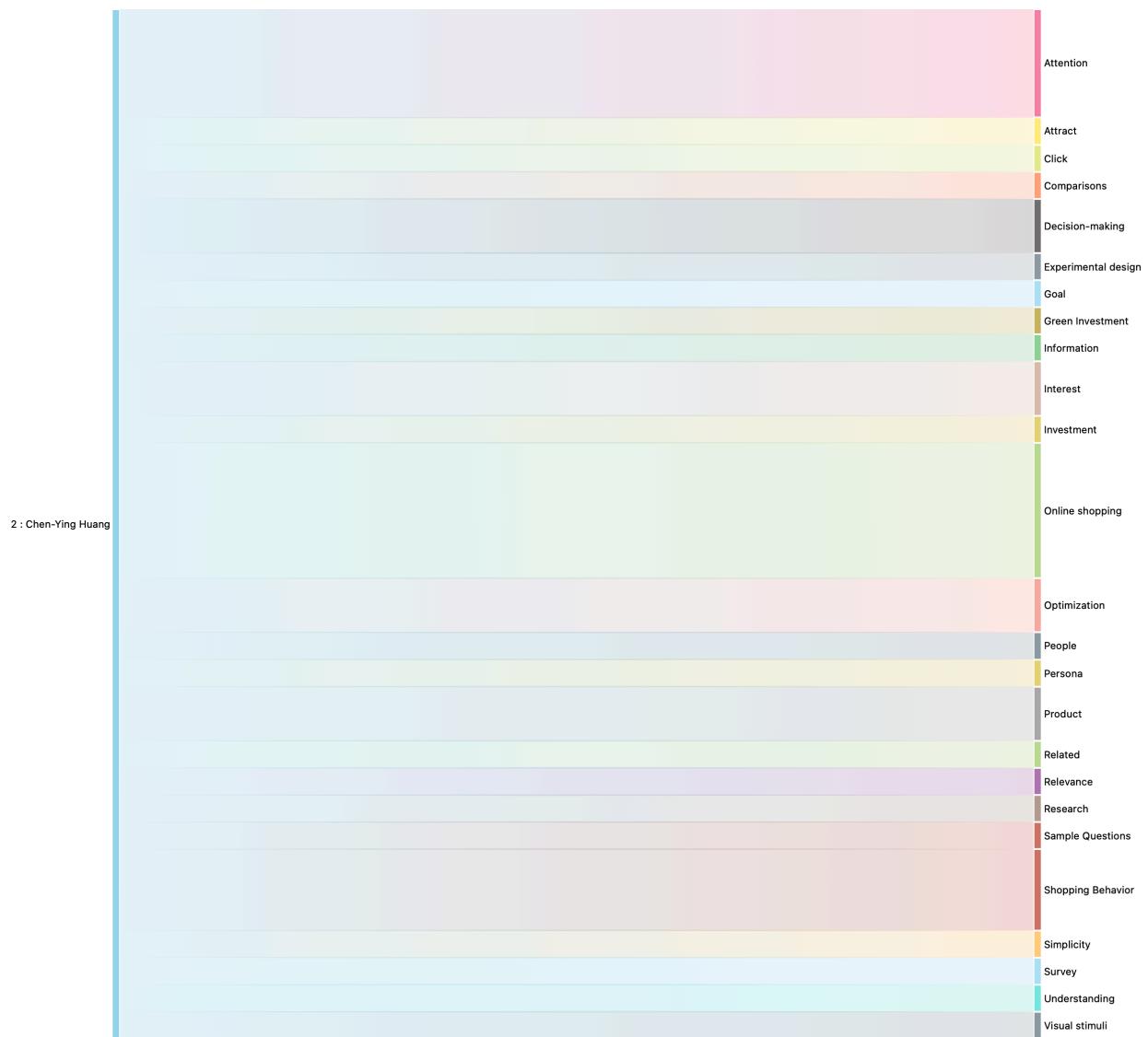


Figure 17: Chen-Ying Huang

Interview 5: Economist - Yuping Chen

Date: 2024-06-04 Expert: Yuping Chen is an economist and professor at National Taiwan University with a focus on marketing and online shopping. Country: Taiwan Topics: Economics, Online Shopping

Key learnings: "I think you are targeting experts instead of a general consumers"

Thematic Analysis.

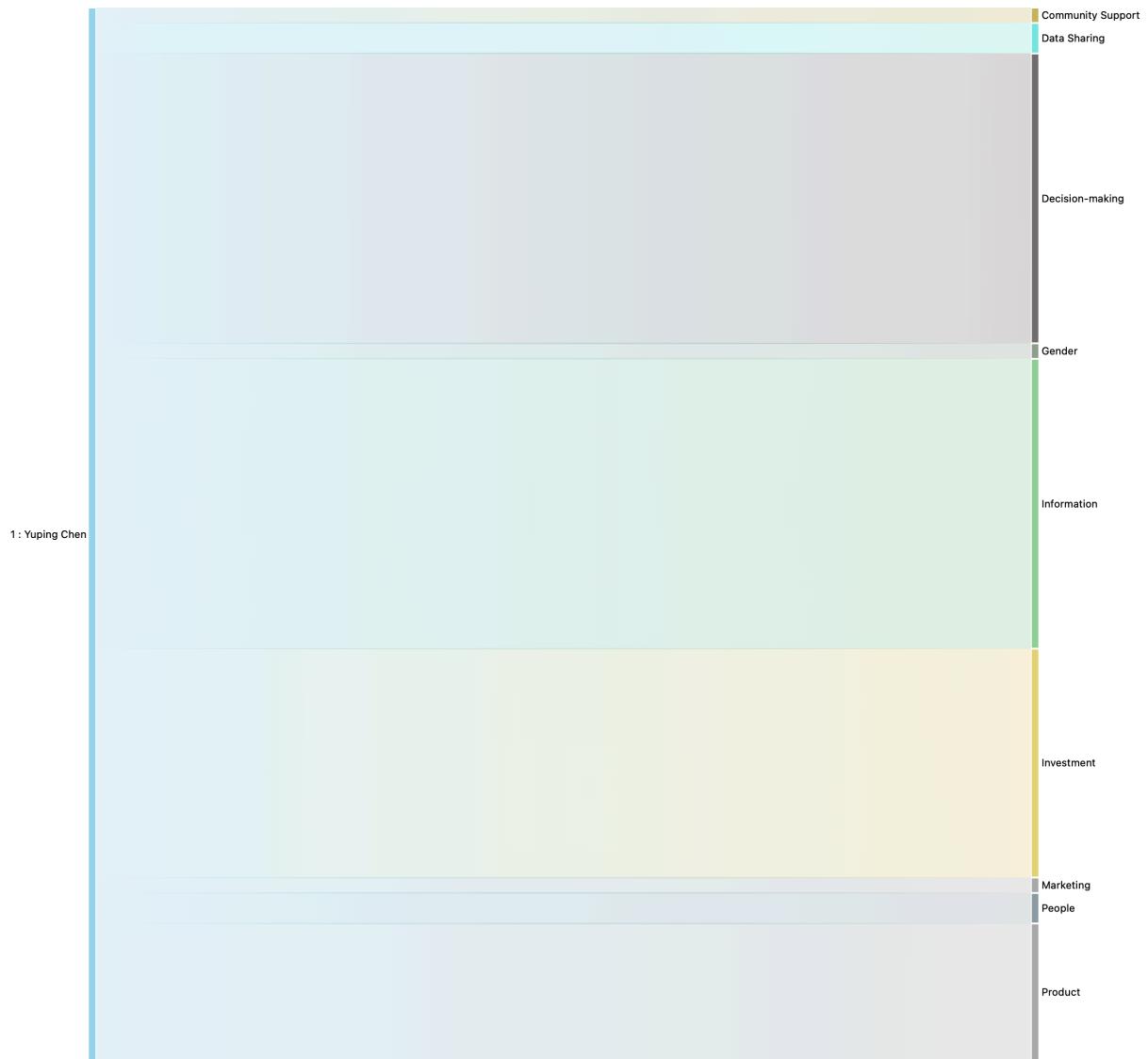


Figure 18: Yuping Chen

Overall

Common topics between all conversations become visible in the overall Sankey Diagram.

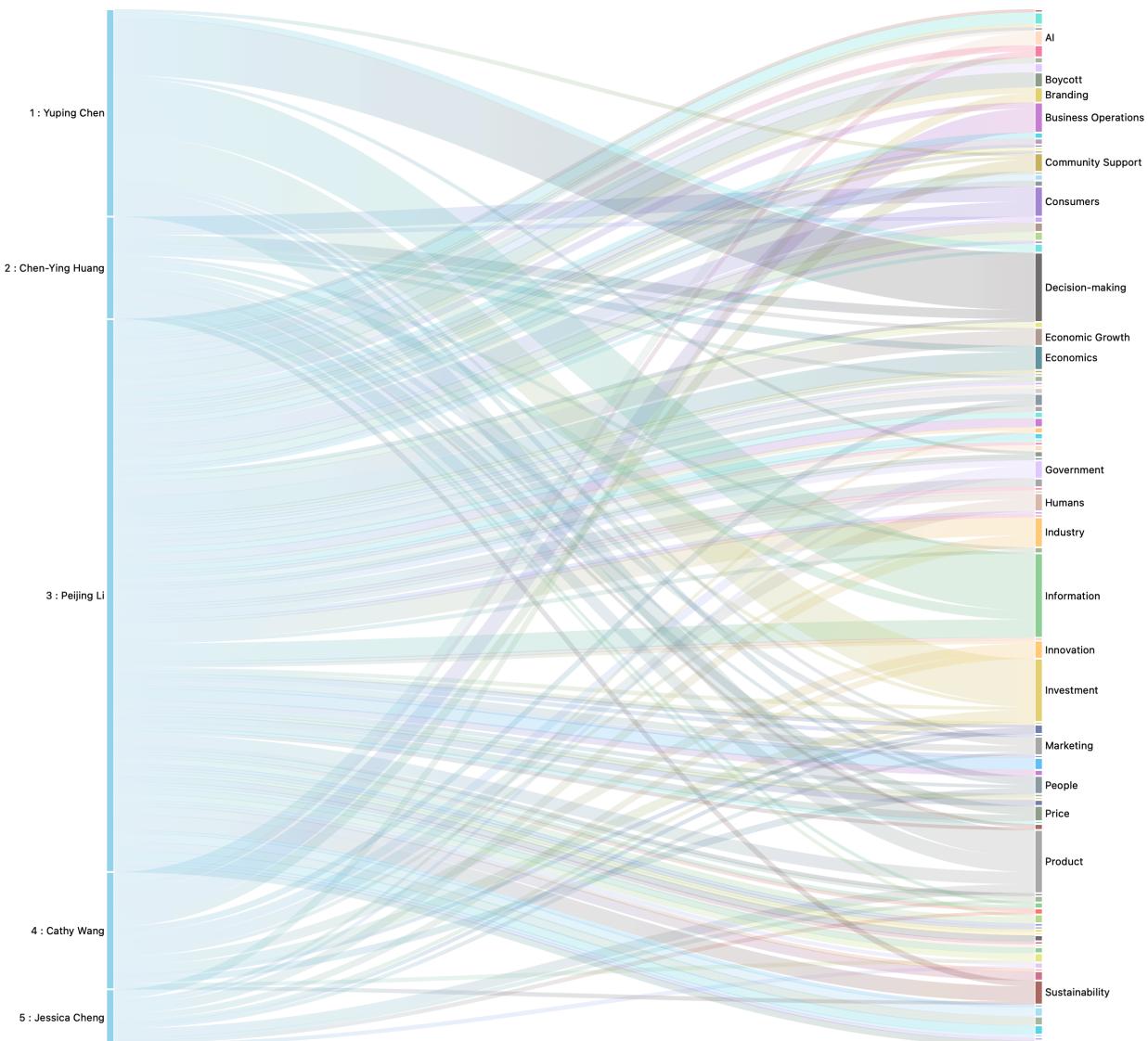


Figure 19: All

Discussion

College Student Willingness to pay (WTP)

Defining the Problem Space.

- college students can get used to looking at financial charts

Mindmaps

Initial version of the concept map focused on the app itself.

Current concept map focusing on sustainability.

What is Research?

I, as the researcher, am similar to the blind people in the elephant story; focusing on greening shopping, saving, and investing are only the trunk of the enormous elephant that is environmental disaster unfolding in front of our eyes.

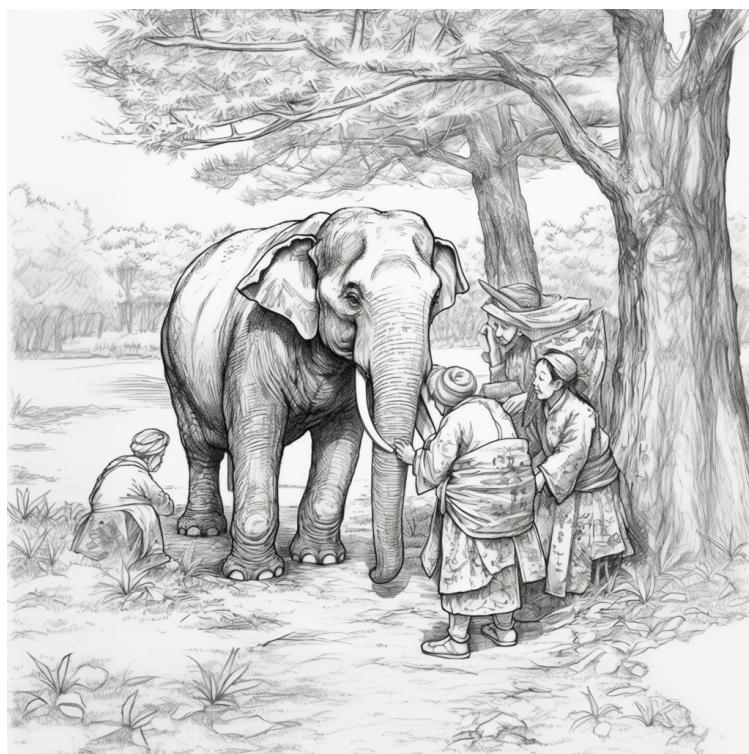


Figure 20: Illustration of the Jainist parable Anekāntavāda also known as “Blind Men and an Elephant”. Generated by Midjourney on August 17, 2023. Prompt: “A simple pencil-drawn illustration of the story ‘Blind men and an elephant’. The man touching the elephant’s trunk is a research scientist. Ohara Donshu, Itcho Hanabusa, Japanese woodcut Edo style”.

- Design research books
- Anon (2011)
- Ries (2011)
- Design Studies Journal

Research through design is a method for *interaction design research* in Human-Computer Interaction (HCI).

- Zimmerman, Forlizzi & Evenson (2007)
- Salovaara (2020) defining a research question
- Nunnally & Farkas (2016)

interview people at google who made the green filter options

- Design artefacts
- “design’s nature as a ‘problem-solving’ science” Oulasvirta & Hornbæk (2016)
- my contribution is the design artefact, “HCI researchers also make constructive contributions by developing new technologies and design”
- Affairs (2013) Card sorting
- Anon (n.d.ak)
- Behaviour kit:

Take the metrics from the several frameworks and display them on the product and company level? People can choose their own framework and see product data through that lens and vocabularies.

Col1	Col2	Col3
Donut Economy	Unrolled Donut	
Regenerative Capitalism	8 Principles	
Blue Economy		
ESG		
B Corp		

- “research for design”. design research is about expanding opportunities and exploration
- RanYwayZ (2016)
- Mehmet Aydin Baytaş (2020)
- Anon (n.d.a)
- Anon (n.d.b)
- Anon (n.d.c)
- Anon (n.d.d)
- Anon (n.d.ae)
- Erika Hall (n.d.)

- Contact Kalle Lasn, Culture Jam
- online/offline ethnographic participant observation At this stage in the research, the central concept being studied is defined generally as user expectations for a sustainable investment app.
- What are my hypotheses?
- User experiments
- Financial statistics
- Analyzing existing apps and user pain-points
- List of topics gleaned from literature review for discussion with the experts:
- Transparency and sources of ESG and similar data
- I will test the prototype with potential users using an online choice experiment survey.
- Research Process In terms of literature review, academic inquiry in social sciences largely follows phenomena, while the issues and technologies discussed here are emergent. Not many studies exist yet (they might in a few years), which is why some of my references are to company press releases and news stories, or for public companies, their advisory for investors.
- Target potential retail investors aged 20-29, all genders, in countries with highly developed financial markets and active social campaigns demanding sustainability (Sweden). And Taiwan. In general, the Taiwanese culture is savings oriented: I'm in a good location for financial user experience research.
- Set your target goals
- Access to health care
- Access to education
- Climate action

I propose *interfaces* and *workflows* to see financial interactions through the filter of sustainability.

What kind of sustainability info do college students care about? How would college students prefer to interact with the AI? What role would college students prefer the AI to take? How can college students trust AI? What can college students do to aid sustainability efforts? How might AI assistants help college students find shopping, saving, and investing opportunities?

“Systemic change through financial actions driving policy and market changes encourage broader industry shifts towards greener practices”.

Overconsumption-driven extractive business practices contribute to the degradation of Earth’s natural ecosystems, pollution of water, air, and soil, deforestation, diminishing biodiversity, climate instability, extreme weather, modern slavery, worsening human health, and other environmental and social challenges (ADD CITATION). Companies are attuned to consumer demand however widespread greenwashing makes it tiring to find sustainability-focused companies and requires extensive time for research. Even for highly motivated people, it’s difficult to know what’s sustainable.

My interest lies in understanding how AI assistants can help conscious consumers become sustainable investors. The purpose of this study is to explore how to provide the best user experience to potential sustainable financial AI companion users. In their sustainability report every company looks perfect. How can people shop, save and invest sustainably? Where does our money go and what are some greener alternatives? The companion enables people to be more transparent and responsible in their consumption behavior.

In Taiwan water is too polluted can't swim

air is too dirty can't breather (show my own stats)

Start local then go global with backup data from global sources

Ask chatgpt how to organize my sections

rq: how to connect env destruction pollution to source causes

rq: how to connect everyday financial actions to environmental impact in a visual/ meaningful way

idea came riding my bike in annan can't swim in yhe annan river

show local pollution map?

show factories on the map

instead of the browser plugging just make a website where you can share the link of the product (and cache rhe results)

on ios can use the share screen to share to the app?

ICID calls upon us to have the courage to redesign entire industries

This research takes place at the intersection of Taiwanese college students, sustainability, finance, AI, and design.

For the average person like myself, my experience with money is mostly limited to buying things at the supermarket. Food, clothes, furniture, soap, mobile phone. This leaves very few options on how to start with something new like saving and investing.

Could the Green Supermarket become the entry point to Green Savings and Green Investing?

Oboarding more people for sustainable practices is a complex interaction design issue hindered by ambiguous data (what is sustainable?) and messy human motivations (we love buying things).

What can people who want to preserve Earth's environment, exactly do? How can networks of people come together?

— LLMs enable data journalists to create stories: Big Local News (2024)

Health tracking apps paired with connected devices such as Apple Watch filled with sensors provide one model for simple interactions to dynamically track digital health data - also known as a quantified self. This data allows apps to provide tips how to improve health outcomes through small daily actions such as climbing more stairs. Small interactions allow users to align their goals with their actions.

What would be a good interface to track sustainability? What is the user interface at scale, useful for billions of people?

One way to influence societal outcomes is to decide where to put our money. While our financial decisions are a vote towards the type of businesses we want to support, is it enough?

While some people are demanding sustainability, and some governments and companies are announcing green investment opportunities, how can consumers discover the most suitable investment options for their situation?

How can retail investors access and differentiate between eco-friendly sustainability-focused investable assets?

The level of knowledge of and exposure to investing varies widely between countries and people.

Could linking green consumption patterns with sustainable investing provide another pathway to speed up achieving climate justice as well as personal financial goals?

In this simplified scenario, I'm in a physical offline store, doing some shopping. When putting a bottle of Coca Cola in my basket, my AI companion Susan will ask me a personalized question:

Does individual climate action help?

Gen-Z college students (target users) may not have the capital to make a financial dent today however they can be early adopter and they will be the decision-makers in a few years.

"Like climate change, the focus on individual actions as a solution is often misplaced, though it remains a focus of media and industry. For decades, the petrochemical industry has offloaded responsibility onto individuals through promoting concepts such as the "carbon footprint", championed in a 2004 advertising campaign by British Petroleum" Lavers, Bond & Rolsky (2022).

Individual efforts are too small to matter unless they're inspired by Community a effort atmospheric pollution and climate change

The latest IPCC report Calvin et al. (2023)

Dimock (2019)

- Latvian Kora app for tracking personal CO2 footprint, Earn KORA coins for reducing CO2 emissions (Kora Sustainability, 2019).

Results

The research helps me (and others) to

- Avoid reinventing the wheel and duplicating existing approaches.
- It aims to help app developers maximize impact by aiding complementary additionality.
- Make high-quality products. If used wisely, money can help build communities of sustainable impact.

Define every word in the title: "The Journey from Consumer to Investor: Designing a Financial AI Companion for Young Adults to Help with Sustainable Shopping, Savings, and Investing"

- Journey - behavioral change takes time
- Consumer - purchase goods without thinking about the effect

- Investor - thinking about the return
- Design - decisions
- Financial - dealing with money
- AI Companion - automated sidekick
- Young Adults - College Students
- Help - to be of assistance
- Sustainable Shopping - shopping understanding the consequences
- Sustainable Saving - in this context I mean Sustainable Savings, that is reducing one's environmental footprint
- Sustainable Investing - activity of thinking longer-term

Open-ended Questions

Close-ended Questions

Expert Surveys

Database

Compile a database on relevant apps and companies in the space

Easily access data used in this research project (please wait a bit until it loads below). The database includes sustainability-focused apps categorized by features and problems they try to solve, sustainable investing apps, and links to research papers.

User Survey

- Factorial Surveys (Li et al., 2022b): “Factorial surveys is a research method that combines classical experiments with survey methodologies. Factorial surveys use short narratives, called vignettes, to represent various levels of independent variables that are too complex or unethical to create and manipulate in real-world or lab situations”

and a including a choice experiment between potential feature sets in consumption, savings, and investment.

Start with a simple but powerful question: — Does it matter what you buy? — Does it matter how much you save? — Does it matter where you invest? Why?

Research Limitations

First, finance is a highly regulated industry and the proposed user experience designs may be limited by legal requirements. This study does not take such limitations into account, rather focusing only on the user experience.

This work is focused on user experience design and does attempt to make a contribution to economics.

ESG data is expensive so couldn't be used in this research. ESG needs data to give us an accurate understanding of the realities inside companies and the user experience design does not address the underlying data quality problem further than by providing a link to the data source.

I don't have access to user financial data.

- Research Reason: While many people are working on AI models, there's a lack of people working on "Human-AI interaction". Sustainability is the context. How can we better team up to solve the challenges we face this century? The huge externalities.

Future Research

The literature is rich and there is ample space for future research. The following includes some suggestions for authors whose work deserves a deeper look.

- Does the specialized interface offer any advantages of a general UI such as ChatGPT, Claude, Gemini, Mistral, and others?

Some ideas for fruitful research directions

- Perception of pollution levels among Taiwanese college students.

Ideas for Interfaces / Scenarios

Show all the different prototypes just like architects do. And then defend why I chose the one I did. For NW make a Loom with the interfaces and talk about them?

Prototypes of Product Features

I developed a number of early prototypes to visualize product feature ideas.

What's on the intersection of College Students, Sustainability, Investing, Data-Driven Design and Artificial Intelligence (AI)? AI-Driven Sustainable Investment Tools.

The app aims to address the market failure by providing consumers sufficient sustainability information on the goods, services and investments.

resource depletion

and adopt the doughnut economy as my overarching theoretical framework

Humans are successful because of our adaptability. The study suggests tools to adapt to our current reality.

United Nations Decade on Ecosystem Restoration

Hypothesis: extractive business practices reduce college students trust, regenerative business practices create trust among college students towards the company.

Provided there is awareness

How can sustainability-minded college students find companies that meet their expectations, standards and requirements?

- Make a public profile of my carbon consumption!!! Like on Commons.
- Shop
- Save
- Invest
- Build closer relationships with sustainability-focused companies
- Sales funnel for eco-focused products
- The eco-friendly market is fragmented
- Build trust, clarity, transparency, and honesty
- Make a ‘Sustainability Flywheel’ graphic, like that of Amazon’s
- Sustainability is fragmented. How can billions of people build closer relationships with sustainability-focused companies based on honesty and transparency? A research project for designing a sustainable shopping, savings, and investing companion.
- Most sustainability plans rely on carbon credits to achieve their goals, making carbon credits a single point of failure. If the credits are not accurate, the whole system collapses.

- TODO: Make a table showing research results translated to design decisions
- Your Green Helper
- Make some initial prototype? make YoutTbe video... hi, you have reached? spread... through ESTBan and others?
- Currently CO₂ footprint calculators ask you a couple of questions and give a ballpark estimate. Does it make sense to track sustainability on a more nuanced level, like Apple Health, in order to encourage sustainable behavior?

Product Idea	Source		Prototype Link
Speak Truth to Power	Literature Review	Consolidate user feedback for companies	greenfilter.app/prototypes/truth-power
Shopping Divest	Literature Review	What if you could build communities based on what you buy?	greenfilter.app/prototypes/shopping-divest
True Cost	Literature Review	What if you could see the actual cost of each product including externalities?	greenfilter.app/prototypes/true-cost-
Sunday Market	Literature Review	First prototype for going to the organic Sunday Market with friends.	
XYZ	Expert Interview		
ABC	User Survey		

- *Affinity diagrams* help users organize ideas by brainstorming, sorting and labeling to cluster related information (Kara Pernice, 2018; Quignard, 2022)
- Scan a product to see the company and start investing or divesting from them Current economics is lowering the quality of life on the planet

Actionable Insights: Translate data into everyday actions the app can suggest.

- What does investing look like at the scale of billions of people? like IG
- The most effective things are Commodities? Food, transport, fashion, plant trees.
- personalized AI, meta glasses understand your context. sense and reconstruct the world around you and to understand the context in which you're using your device.sense and reconstruct the world around you and to understand the context in which you're using your device. Make suggestions and take action proactively to help you get things done — ideally, so seamlessly that you may not even notice.neuroscience co-adaptation of the interface. your future devices will learn and adapt to you as you use them.
- Scalable Climate Solutions: What really works on a large scale?
- brand colors: pink, orange, green

Shopping-as-Investing

- Introduce this concept
- The Manor (2022)
- Sustainability is hard. Green Filter helps you find companies that are making a true effort and build closer relationships through shopping, savings, and investing. Green Filter helps you find companies that are making a true effort to become sustainable and build closer relationships through shopping, savings, and investing
- Gather requirements and build a prototype for the next-generation investment app for young adults. Improving the user experience for young adults getting started with (green) investing. What would a “Tinder for (Green) Investments” look like? How can we make the logistics of investing so easy to use and take into account my values?
- My thesis core message is : everyone should change from consumer to sustainability investor (define these terms in the thesis). how to do this? can help you become from consumer to investor i believe there's space for a product like that. your green investing friend find the companies tackling certain problems and invest in them using crypto business can be a force for good
- Consumer purchases are an indicator of demand. If demand trends down, companies will stop producing this product.

'Investment-as-Product'

- Green Filter helps you discover how to save money and the planet with your daily shopping. By providing an easy way for people to learn about and shop with sustainable companies, we imagine a world where people invest in their future, find great deals on responsibly-made products, and get useful discounts from socially responsible brands.
- GreenFilter is a product that combines AI, design and marketing to help people manage their social impact throughout the stages of their lives, from young adult years to retirement. Its primary goal is to give people the tools they need to invest responsibly in sustainable companies, while also educating them on this topic. Our project offers a responsive website and mobile app that leverages AI and other advanced technologies. In addition, our prototype includes a reality-based virtual assistant with voice command capabilities which can provide customers with new insights into the world of green finance
- GreenFilter introduces a novel, interactive point-of-sale technology that helps people make greener shopping decisions. The platform uses artificial intelligence to suggest green alternatives for products on your shopping list, and will also help you to find other companies that can make sustainable versions of the product you are buying.
- As people become aware of the impact their shopping is having on the environment, they become interested in finding alternatives to big brands and large companies. GreenFilter provides designers an AI companion design which helps people build relationships with sustainability-focused companies by providing personalized recommendations, giving product reviews and helping them shop sustainably. This new tool will empower consumers to make greener choices throughout their lives.

- Better management of planet Earth
- How can we Shop, Save, Invest in line ecologic principles and planetary boundaries? individual action doesn't move the needle. how to group together
- App to build community
- Life within planetary boundaries
- Currently it seems there's a secret around how things are produced we want to increase transparency
- Companies that have nothing new nothing to hide should welcome this opportunity to mark themselves to keep a conscious consumers and investors.
- We want to create competition around sustainable practices enter widespread adoption
- Cigarettes and pictures of lung cancer every product should be required to have photos of production conditions switch such as Rainforest and deforestation the products that include Palm oil.
- My thesis is that a lot of people want to do good, shop eco-friendly, invest green, etc. But they don't believe the solutions work. They don't have trust. This is a user interface issue. How to build trust.

Early Feature Ideas

The following early prototypes are focused on particular feature ideas that occurred to me during the literature review process. They are naive and meant to allow thinking in terms of *what-if* a particular user experience was possible. These prototypes were not tested with users directly and formed a basis for directing the questions asked in a potential user survey.

Susan (Sustainability Conversation)

What if I could have a chat like this at the supermarket? Imagine what questions I would ask before buying a product. AI: “Kris, do you still remember Coca Cola’s packaging is a large contributor to ocean plastic? You even went to a beach cleanup!” Me: “That’s so sad but it’s tasty!” AI: “Remember your values. Would you like to start saving for investing in insect farms in Indonesia instead? Predicted return 4% per year, according to analysts A and B.” If I’m not so sure, I could continue the conversation. Me: “Tell me more” AI: “A recent UN study says, the planet needs to grow 70% more food in the next 40 years. Experts from 8 investment companies predict growth for this category of assets.” Me: “Thanks for reminding me who I am” ... Moments later. AI: “This shampoo is made by Unilever, which is implicated in deforestation in Indonesia according to reporting by World Forest Watch. Would you consider buying another brand instead? They have a higher ESG rating.”

Example Suggestions of the AI companion:

- “Don’t buy a car, use a car sharing service instead to save XYZ CO2. Service available near you: Bolt,* Uber.”
- “Use a refillable shampoo bottle to save XYZ plastic pollution”
- “Call your local politician to nudge them to improve bicycle paths and reduce cars in your neighborhood. Over the past 2 years, your city has experienced an increase of cars from 290 cars per capita to 350 cars per capita.”*

Figure 3: Speculative scenario of an interaction between a human user and a robo-advisor through the interface of chat messages in the context of retail shopping for daily products.

https://scontent.ftpe6-1.fna.fbcdn.net/v/t39.8562-6/333078981_693988129081760_4712707815225756708_n.pdf provides many examples conversations between AI and humans from Meta’s LLAMA mmodel

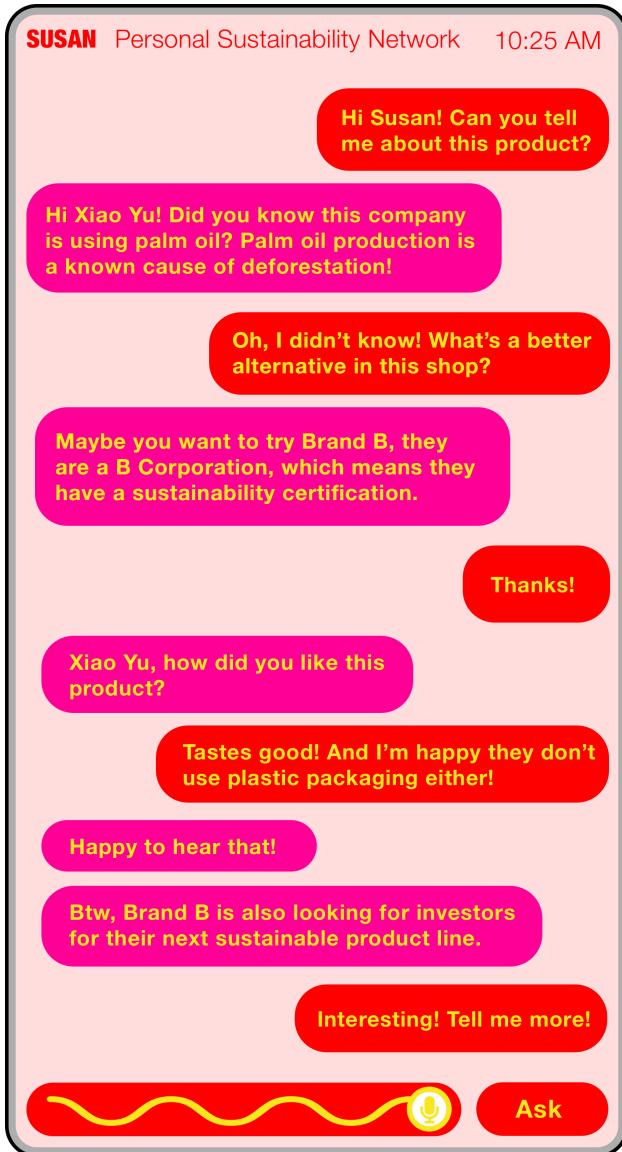


Figure 21: Early prototype of my Sustainable Finance AI Companion (Nov. 2020)

Sunday Market

What if I could go to the Sunday market with other people who care about sustainability? First prototype (based on literature review) called HappyGreen's for going to the organic Sunday Market with friends. Choose industries of focus? Fashion, Food, etc?

True Cost

What if I you could see the actual cost of each product including externalities?

Speak Truth to Power

What if I could affect companies with truth? Consolidate user feedback for companies.

How Far?

What if I knew how far did this product travel to reach me?

Country Profiles

What if I knew my country's top pollution sources?

Know Your Company

What if I could KYC the companies I interact with? Like the banks KYC, consumers can KYC.

CO2e Flex

What if I could show off how much CO2e I have retired?

Sustainability Watch

What if I could see all my sustainability data on a wearable device in the right context?

Narrative Layouts

What if I spent 5 minutes every day with a guide who could help me make more eco-friendly choices? How should the layout storyline be structured? Well it's like Strava (that running app) for sustainability... or if you have heard of Welltory. I believe sustainable choices that would improve my life.. be it what I consume, save, invest, etc.. so I'm trying to design an app around this idea. I'm basically building the UX of AI.. focused on sustainability. How should the layout storyline be structured? Well it's like Strava (that running app) for sustainability... or if you have heard of Welltory. I believe if I spent 5 minutes every day with a guide who could help me make more eco-friendly choices that would improve my life.. be it what I consume, save, invest, etc.. so I'm trying to design an app around this idea.

Shopping Divest

What if I could build a community based on what I buy?

Books Can Talk

What if sustainability literature could chat with me? Books can now talk to me. My bedtime story about shopping, saving, and investing. (Anon, 2023af)

- (Ray Kurzweil, 2018)
- (Bailey, 2023)

Interactive Prototype

- <https://ai.ziran.tw/>
-

Testing

Retrieval-Augmented Generation (RAG)

- “make contextual decisions on-the-fly, thereby opening up a more dynamic and responsive way to handle knowledge search tasks” Dewy (2024)

Prototype Development

– tools used: qr generator in Canva postman for API testing

- Google Chrome has 3.45 billion users Anon (2023m)
- Retrieval-Augmented Generation (RAG) to enhance AI content with domain-specific (close-to realtime) knowledge.
- technique first proposed by researchers at META (Lewis et al., 2020) some RAG benefits include [Gao et al. (2023);]

Prototype architecture

- Google Chrome browser extension
- API microservice
- Ziran AI
- AI backend
- Ratings API
- Redis testing ai results
- Redis Page cache / from page / separate scraping service
- documentation: GreenFilter: thesis website / github
- Ai API got / claude
- Stock ratings API
- Community ratings api

70 questions questionnaire - use report ID to do anonymous testing - page tracking to track the usage - 7 app questions - 63 personality question

Testing

Does the prototype match user needs?

Testing was the most difficult part of the thesis process.

- Testing with friends and acquaintances.
- Testing with experts.
- Testing with unknown people in the target audience.

App Testing Flow

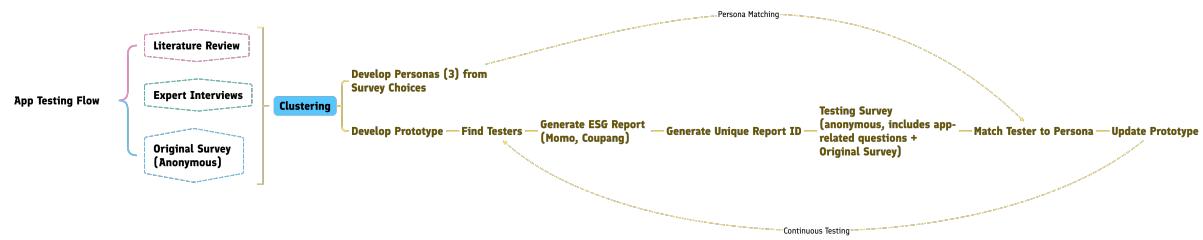


Figure 22: App Testing Flow

Testing Period

- 1 month from 2024 April 2 to May 2, 2024
- 30 individual participantsbö

Testing

Prototype Testing results

sun, 14. april. 22h at D24

- NCKU student, gen-z
- searches for lancome brand
- chooses LANCOME 蘭蔻 小黑瓶 100ml(買一送一/超未來肌因賦活露國際航空版)
https://www.momoshop.com.tw/goods/GoodsDetail.jsp?i_code=12028429&Area=search&oid=1_8&cid=i
- notices 買一送一
- doesn't notice analysis button at first
- would only click on this if it's really expensive
- would not click on "continue chat button"
- asked "why is it so expensive in taiwan2"
- considers report result useful

note: there's dropoff on every step of the user journey

RQ: To what extend can shopping become an entry point for saving and investing. RQ: Can shopping serve as an entry point for sustainable saving and investing?

Testing overview

- Tested with 30 participants individually
- Testing is anonymous
- Generate
-

有意識的消費主義

- add carbon indicators, other labels to the analysis, add report code, calculate report code from URL? save as kv

may 8 czuta

- investment help useless.. needs simpler intro - wants to see real cows - very curious about companies - wants to see profit percentage. why is margin so high if pollution is bad. - real environmental impact of the company.

06 may - Seeing factory photos is useful only if they are trustworthy photos. Who will provide them? -

may 5

- user: it looks like an ad

may 3

- uses google to look for "fashion brand eco friendly"
- thinks "goodonyou.eco" looks like a brand website

may 3 - first looked for NET clothes but Momo doesn't sell it - Looked for Sony camera lens

1 may prof suggestion - make connection between biodiversity and production and consumption clearer - what is the incentive for companies to share their data?

my own idea: like the switch of going from traditional banking with ATM machines on the street (or even the physical bank office) to online banking with mobile payments

- hypothesis: esg accessibility can push companies to increase production standards
- what if you can see ESG in near-realtime such as the stock market price
- i can imagine esg derivative product like siemens gamesa
- ai can help integrate esg derivatives into daily life to drive esg adoption

- “effective altruism (EA)”
- “Blockchain technology can improve price transparency in product distribution by allowing consumers to know the exact pricing from raw materials to distributors to suppliers.”
-

Interviews and testing survey were conducted anonymously in hopes to have more honest responses from the responders.

- ziran chrome extension is unable to record activity due to browser security restrictions for plugins
- ai.ziran.tw record user activity
- semi-structured interviews were conducted in chinese
- the interviewer (me) took notes of the interviews
- some gaps in the data exist due to the limited chinese language skills of the interviewer (me)

basic interview script - momo: what is a brand that you like'd or would like to buy - search - please pick a product (or search again) - on product page: what do you notice on this page? - what kind of information is important for you on this page? - do you notice anything else - (if the user doesn't notice the green filter, direct their attention to it and ask: what do you think this does?) - would you click on it - if the user says yes, continue - if the user says no, make note and continue - as the extension generates a response: what do you think about this content? - is there any information that you consider important? - anything else you see that you think looks special - do you see anywhere you can click? - would you click on it? - if yes, continue - if no, make note, and continue - explain: due to the limitation of the prototype, the test will continue on a separate page where you can ask questions - is there anything you would like to ask the helper? - notice if the user picks from sample questions - remind the user they can come up with their own question - as the ai is generating content ask: do you see any information in this content - did you know this before or is there any info you didn't know before? make note. - front page: explain the helper takes into account your personal info and goals. - ask: what kind of information do you think important to share with the helper?

Tuesday 30. April 14:05-14:45 - 7CYQ6

- Momo
- Looks for Levis pants
- Looks for recommendations on the sidebar
- Looks at the photos
- Looks at the price and options
- Didn't notice the helper as it looks like an ad
- When helped
- Ignores 社區支持: 購物 69% 儲蓄 80% 投資 65% as doesn't know what these mean
- on ai.ziran
- shares personal info: 四年後想考研究所, 還不想工作, 所以不會存到錢, 希望可以考到台北的學校, 每個月有兩萬生活費。
-
- DJmoney
- <https://www.moneydj.com/etf/x/basic/basic0004.xdjhtm?etfid=0050.tw>
- Still didn't notice the helper

- Doesn't understand investing (Understands it's Taiwanese stocks) so the helper is useful for explaining new concepts

Monday 29. april 10:10-10.25 - Momo - buy new balance sneakers

- DJmoney
- wants compare EFTs

Monday 29. april 14:50-15:10 - Momo - buy apple iphone - bad internet - app was slow - app crashed

- green filter analysis on DJmoney seems more trustworthy than other 2 eft sites
- button placement is important (too low on other sites than djmoney)

Sunday 28. april 16:00 - momo: wants to buy ice cream

sun, 14. april. 22h at D24

- ncku student, gen-z
- searches for lancome brand
- chooses LANCOME 蘭蔻 小黑瓶 100ml(買一送一/超未來肌因賦活露國際航空版)
https://www.momoshop.com.tw/goods/GoodsDetail.jsp?i_code=12028429&Area=search&oid=1_8&cid=i
- notices 買一送一
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<https://www.youtube.com/watch?v=xLszCaeUWig>

<https://www.youtube.com/watch?v=GHMAboJvLCU>

<https://www.youtube.com/watch?v=xLszCaeUWig>

<https://www.carbonequity.com/what-we-offer>

Expert Feedback

- Provide alternatives
- Simplify text
- Use images
- Put a “New Feature” ad on the front page
- Change 繼續討論 to something more actionable
 - I tried changing to “see alternatives”

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Anon (2021r) 台灣設計研究院（TDRI）on Instagram: ”北歐循環設計論壇 | 開放報名中 - 近幾年，全球的極端氣候造成各地災害頻傳，人們更加意識到要珍惜地球資源，丹麥從 10 幾年前就開始推行低碳生活，哥本哈根海洋上成排的風力發電機供應丹麥 20% 以上的能源，哥本哈根的學校建造出全世界最大的太陽能板，甚至丹麥的設計團隊進行設計皆從永續環境為本心出發，在丹麥，每一個生活環節都是循環設計！ - 但丹麥談的循環永續不只是不具經濟效益的理念，循環經濟對丹麥來說不僅具有環境層面的效益，還可提升企業的競爭力，對資源生產力、就業機會、資源供應安全和自然資源的可持續利用都有極正向的回饋。 - 本次國際論壇，我們邀請來自丹麥的設計師 Ditte Lysgaard Vind 從循環經濟策略、Rosa Nøss Bendixen 從產品設計、Helene Jensen 從時尚產業、更有台灣的團隊奇想創造、光寶科技、REnato Lab 從不同產業類別，以跨領域的思維，分享他們循環再造的創意點子！ - 北歐循環設計論壇 Nordic Circular Design Forum 活動日期 | 11 / 12 (五) 16:00 ~ 18:20 講座方式 | 線上直播與線下參與 講座費用 | 免費 報名 | 請至個人檔案點選 #TDRI #台灣設計研究院 #設研院 #設計 #design". *Instagram.* <https://www.instagram.com/p/CWC6KG7sXBJ/>.

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