Fanzine by Jude Thompson with text by Matt Brennan.
Economic cost research by Matt Brennan with assistance from Paul Archibald.
Environmental cost research by Kyle Devine. Graphic design by Jude Thompson, Graeme O'Hara, and Martin Elden.

"Build A Thing of Beauty" album produced and mixed by Andy Monaghan.
Additional engineering by Matt Brennan and Gavin Thomson. Mastered by Paul Gallagher. All songs written by Matt Brennan.
All music played and sung by Matt apart from: bass guitar and occasional studio wizardry by Andy Monaghan.
Additional guitar on tracks 6, 7, 9 and riddle on track 10 by Malcolm Benzie. Backup vocals on tracks 3, 5, 6, and 9 by Anna Miles.
Strings on tracks 1 and 6 by Pete Harvey and the Pumpkinseeds.
Trumpet on tracks 1 and 8 by Yati Durant. Saxophone on tracks 9 and 10 by Raymond Macdonald.
Ian MacKaye speech sample on "Have A Nice Time" used with kind permission from Dischord Records. Album cover design by Bertrand Mougel.

CSI FI HI FI conceived and designed by Matt Brennan.
Peter Reid and Mark Reynolds with assistance from Aleks Kolkowski and Duncan Miller. Machine learning album remix by Owen Green.

Citizen Bravo one man band suitcase conceived and designed by Matt Brennan and David C. Frazier.

Thanks to the Arts and Humanities Research Council for supporting this project.

Did this fanzine change the way you think about consuming music?
If so, I’d love to hear from you:
E-mail: matt.brennan@glasgow.ac.uk
Twitter: @MattBrennan

Even just a sentence or two of feedback on how (or indeed, whether) this fanzine changed your thinking will be very helpful for the development of new research projects (and fanzines!) on the wild and wonderful relationship between music and society. Thanks!

CITIZEN BRAVO AND FRIENDS PRESENT THE TERRIFYING MIRACLE OF RECORDED SOUND
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Hi! My name is Matt and this a fanzine I made with artist Jude Thompson. Other friends who helped were Kyle Devine (environmental cost research), and Graeme O’Hara + Martin Elden (infographics). It’s all about the terrifying miracle of recorded sound!

By day, I teach on a master’s degree about the music industries at the University of Glasgow. By night, I make music in a one-man band called Citizen Bravo. I recently recorded an album called “Build A Thing of Beauty,” and when it came to releasing it I began to wonder about the changing economic and environmental costs of different recording formats over time. What percentage of their disposable income were consumers willing to pay for the luxury of listening to recorded music at different points in history? And which recording formats were the most environmentally sustainable? These are interesting research questions.
Nowadays most people listen to their music on digital devices, but check out the photo below from the 1890s: Look at the excitement on the faces of these young women gathering around a phonograph wearing listening tubes (a lot like white Apple earbus!), all without electricity.

You can see that this is an extraordinary moment for the people listening. It’s a special, memorable experience. But in the 21st century, listening to recorded music has become an ordinary and even mundane activity. How do we transform the ordinary activity of listening to recorded music back into an extraordinary experience? Let’s find out.
**THE EDISON**

**PHONOGRAPH**

"THE ALME OF REALISM"

"LOOKING FOR THE BAND."

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**HOW IT WORKS:**

Invented by Thomas Edison in 1877, the phonograph was the first viable sound recording and playback device. Phonographs worked without the use of electricity! Sounds (i.e. pressure waves traveling through the air) were performed into a conical horn, and the sound waves were then picked up by a very thin membrane (i.e. diaphragm) attached to a needle (i.e. stylus). The vibrating needle then engraved the vibration patterns into hill-and-dale grooves on the surface of a rotating cylinder.

To play back the recording, the surface of the cylinder was similarly rotated while a sapphire playback stylus traced the groove. The stylus moved along the engraved sound vibrations and faintly reproduced the recorded sound, which was then amplified acoustically through the horn.

In terms of storing sound, however, the cylinder and phonograph were very limited: most cylinders could only store about two minutes of lo-fidelity monoaural sound each.
**ECONOMIC COST:**
The cylinder format's peak year of production in the USA was 1907, when 28 million cylinders were manufactured. In today's money (adjusted for inflation), the illustrative price of a cylinder in that year was roughly $13.88.¹

**ENVIRONMENTAL COST:**
In the 19th century, cylinders were made of wax-like substances made from animal fats like beef tallow and processed paraffins like coal-based "stench-wax." As things evolved, cylinders were made from all kinds of things—from household tinfoil to whale spermaceti, and finally celluloid and a synthetic called condensate.²

¹ All figures in US dollars. You can access the dataset and methodology used to estimate these economic costs at www.citizenbravo.com

² You can learn more about the environmental costs summarized in this fanzine by picking up a copy of Kyle Devine's book, Decomposed: The Political Ecology of Music (MIT Press, scheduled for publication in early autumn 2019).
HOW IT WORKS:
Invented by German-American immigrant Emile Berliner in 1887 (ten years after Edison created the phonograph), the gramophone improved on the design of the phonograph by using flat round discs as a storage format instead of cylinders. These spun horizontally at 78 rotations per minute while a stylus read engraved disc grooves back and forth (as opposed to up and down grooves like the cylinder). Discs came in different sizes, but typically stored roughly three minutes of sound on each side.

ECONOMIC COST:
The 78 rpm disc format's peak year of production in the USA was 1947, when 325 million discs were sold.

In today's money (adjusted for inflation), the illustrative price of a 78 disc in that year was roughly $10.89.¹

¹You can access the dataset and methodology used to estimate these economic costs at www.citizenbravo.com
ENVIRONMENTAL COST:
A key component of gramophone discs is shellac, a natural material produced by lac beetles in India. Lac beetles cover trees in lac resin each year as part of their reproductive cycle. The beetles die in the process, leaving their eggs and lac resin stuck to the trees. This lac is then harvested, processed washed, dried, and melted - before being shipped to a disc factory. Inside American disc factory, for example, various ingredients for 78 rpm discs would be combined with shellac as an important but minority component, while the majority ingredients for discs were locally sourced limestone and slate used as filler material.²

² See Devine 2019, and also Jacob Smith’s Eco-Sonic Media (University of California Press 2015).
HOW IT WORKS:
The vinyl LP arrived in 1948, taking us away from the acoustic era, where most phonographs and gramophones operated without electricity, to the electrical analog era. Columbia Records unveiled the 12-inch 33 1/3 LP in 1948, and in 1949 RCA-Victor introduced a rival format, the 7-inch 45 rpm single. But it was the LP that extended the possibilities for the length of a recording on a single disc, from roughly 3 minutes to roughly 20 minutes on each side — a big jump.
**ECONOMIC COST:**
The vinyl LP format’s peak year of production in the USA was 1977, when 344 million albums were sold. In today’s money (adjusted for inflation), the illustrative price of an album in that year was roughly $28.55, equivalent to 4.83% of a US citizen’s average weekly salary at the time.\(^1\)

**ENVIRONMENTAL COST:**
Vinyl records mark the beginning of the plastic era of recording. To play music in this era you’re not only now consuming electricity (an energy cost) but you’re consuming polyvinyl chloride (PVC) plastic. This is a new material cost, which begins to have important implications for the environment. Roughly 58 million kilograms of plastic were used by the US record industry in 1977 – the peak production year of the vinyl LP.\(^2\)

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\(^1\) You can access the dataset and methodology used to estimate these economic costs at www.citizenbravo.com

\(^2\) See Devine’s Decomposed (September 2019, MIT Press).
HOW IT WORKS:

The cassette tape format was developed in Belgium and introduced by the Philips Corporation in 1963. Tape recorders use an electromagnet that encodes audio signals onto the magnetic coating of the tape strip. A reverse process is used to read the encoded magnetic tape for playback. The cassette overtook other tape-based competitors (like the 8-track cartridge and reel-to-reel) thanks to its portability and sound quality.

The cassette's popularity grew in the 70s and 80s thanks to new portable playback devices like the boombox and the Walkman (1979), allowing users to easily take their music with them.

ECONOMIC COST:

The cassette format's peak year of production in the USA was 1988, when over 450 million cassettes were sold.

In today’s money (adjusted for inflation), the illustrative price of an album on cassette in that year was roughly $16.66 US dollars.¹

¹You can access the dataset and methodology used to estimate these economic costs at www.citizenbravo.com
ENVIRONMENTAL COST:

Once again, the key ingredient for cassettes is plastic: the tape itself is a 1/8" wide polyester-type plastic film, which is passed and wound inside a protective plastic case.

Roughly 56 million kilograms of plastic were used by the US record industry in 1988.\(^2\)

\(^2\) See Devine’s Decomposed (September 2019, MIT Press).
CD Compact disc

HOW IT WORKS:
The CD is a digital-optical data storage format that was co-developed by Philips and Sony and released in 1982.

It can hold up to about 80 minutes of uncompressed audio, which is digitally encoded and then read by a semiconductor laser beam.

The first portable CD player, or Discman, was released by Sony in 1984.
**ECONOMIC COST:**
The compact disc format's peak year of production in the USA was 2000, when over 942.5 million albums on CD were sold. In today's money (adjusted for inflation), the illustrative price of an album on CD in that year was roughly $21.59 US dollars.¹

**ENVIRONMENTAL COST:**
The key ingredient for CD's is still plastic. Roughly 61 million kilograms of plastic were used by the US record industry in 2000.²

¹You can access the dataset and methodology used to estimate these economic costs at www.citizenbravo.com
²See Devine's Decomposed (September 2019, MIT Press).
mp3 on hard drive

**HOW IT WORKS:**

MP3 is a coding format for digital audio published in 1993. It works using compression to encode data by eliminating large amounts of information that aren't easily audible by the human ear, allowing for a big reduction in file size when compared to uncompressed audio.

The small size of MP3 files led to a boom in the distribution of music over the Internet in the mid to late 1990s, when bandwidth and storage were still very restricted.

This created a market for MP3 players, and the most successful of these was the iPod, which was first released by Apple in 2001.
ECONOMIC COST:
The MP3 format's peak year of sales in the USA was 2012 for singles, when over 1.39 billion digital singles were legally sold; and 2013 for albums, when 118 million digital albums were legally sold. In today's money (adjusted for inflation), the illustrative price of a digital album in 2013 was roughly $11.11 US dollars - or roughly 1.22% of a US citizen's average weekly salary in that year.¹

ENVIRONMENTAL COST:
When downloading took over, the amount of plastics used by the US drops dramatically. The impact of the digital download market is difficult to separate from the impact of streaming, which we will consider next.²

¹You can access the dataset and methodology used to estimate these economic costs at www.citizenbravo.com

²See Devine's Decomposed (September 2019, MIT Press).
<table>
<thead>
<tr>
<th>Units Sold</th>
</tr>
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<tbody>
<tr>
<td>200,000,000</td>
</tr>
<tr>
<td>1890</td>
</tr>
<tr>
<td>1892</td>
</tr>
<tr>
<td>1894</td>
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<td>1896</td>
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<td>1944</td>
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<tr>
<td>1947</td>
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<tr>
<td>1950</td>
</tr>
</tbody>
</table>
EDUCATION HISTORY

Music Numbers Across Time

Find and methodology used to create this chart at www.citizenbravo.com
Format Prices in Peak
(Adjusted for

The prices in this chart are illustrative of the amount that American consumers typically paid for each format in its peak year of production.
PRICE HISTORY

Production Years

1988  $16.66
2000  $21.59
2013  $11.11

For Inflation)

All figures for the USA only and in US dollars. You can access the dataset and methodology used to estimate these economic costs at www.citizenbravo.com
Streaming music took off in the mid-2000s, and the key company to make streaming commercially viable was Spotify, a Swedish company that launched in 2008. Streaming platforms use different digital encoding formats; Spotify, for instance, uses a compression format called Ogg Vorbis rather than MP3.

The advent of streaming music resulted in a radical break with the previous economic model of selling recorded music. What used to be a commodity industry (buying copies to own) is now a service industry (buying access to a temporary experience of music stored on the cloud, i.e. server farms).

Streaming technology also opens up new possibilities for making music. My friend Owen Green is working at the University of Huddersfield on a project about music and machine learning, and he offered to make a streaming remix of my album that was artificially composed by a machine-learning computer.

Compared to two minutes of lo-fidelity mono sound on wax cylinder, the algorithmically composed remix of the album will be unstoreable, generative, and infinite in length. You can stream this non-human remix on www.citizenbravo.com
Take a look at the infographic on the next page. As you can see, the absence of physical formats for storing music also led to a marked decrease in estimated plastic use by the recording industry.¹

¹Devine 2019.

You can learn more about the environment costs summarized in these Infographics – as well as the methods used to calculate them – by picking up a copy of Kyle Devereux’s book, Decapitated: The Post-Terror Ecology of Music (MIT Press).

Things into figures for greenhouse gas emissions (e.g. carbon dioxide equivalent or CO2e).

These figures indicate the amount of plastics used by the recording industry removed from the environment.

TOTAL KILOGRAMS OF PLASTIC ACROSS ALL FORMATS (1977-2016)
<table>
<thead>
<tr>
<th>Year</th>
<th>Carbon Dioxide (CO₂) Production (Gt)</th>
<th>Total: Total CO₂</th>
<th>Total: Total for all Formats (1977-2016)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1977</td>
<td>0.172</td>
<td>172</td>
<td>172</td>
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<tr>
<td>1988</td>
<td>0.220</td>
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<tr>
<td>2000</td>
<td>0.338</td>
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</tr>
<tr>
<td>2016</td>
<td>0.406</td>
<td>406</td>
<td>406</td>
</tr>
</tbody>
</table>

Carbon dioxide production plays a crucial role in the environmental impact of various formats. Each format has its own carbon footprint, contributing to the overall environmental impact. The chart above illustrates the total carbon dioxide production from 1977 to 2016, with each year's production value indicating the environmental impact of that year. The total production for all formats, from 1977 to 2016, is also shown, highlighting the cumulative impact over time.
ECONOMIC VS. ENVIRONMENTAL COST

We’ve seen how the economic and environmental costs of recorded music have changed dramatically across formats and over history. It’s clear that streaming on digital devices is the bargain of the century for consumers. Access to so much recorded music has never cost so little!

But in some ways this makes it harder for artists, especially those at the grassroots level, to earn a decent level of income from recording. In 1977 American consumers were willing to spend 4.83% of their average weekly salary to buy a vinyl album, but by the time of the digital album download’s peak in 2013, consumers were only spending 1.22% of the USA average weekly salary to buy an album. It’s difficult to accurately estimate how of the money we spend on digital listening trickles down to artists due to the different royalty deals artists sign with record labels, publishers, management, and other intermediaries. But it is safe to say that compared to earlier periods in history, streaming has driven down the economic cost of music (at least in its digital form).
We might also think that the transition from physical to digital formats has meant that listening to recorded music has become more environmentally sustainable, and while it arguably has from a plastic use perspective, the CO2e costs of recorded music have actually increased substantially in recent decades, as the infographic on the previous page illustrates.

Counterintuitively, then, while the economic cost of listening to one’s choice of recorded music has never been lower, the environmental cost - at least from a carbon emissions perspective - has never been higher.
I wanted to find a way of presenting the ideas covered in this fanzine to the public, so I decided to release my album, *Build A Thing of Beauty*, in a slightly unorthodox way.

The album is available on all digital platforms via Chemikal Underground Records (I recommend Bandcamp if you want to download it), but the only physical release of the album is an interactive musical sculpture known as SCI*FI*HI*FI.

Built in collaboration an electronics engineer (Peter Reid), metal worker (Mark Reynolds), and software coder (Owen Green), the SCI*FI*HI*FI is what its name suggests: a science-fiction inspired hi-fi system that can play seven of the most historically significant recording formats (Edison wax cylinder, 78 rpm disc, vinyl LP, cassette tape, compact disc, mp3 on hard drive, and streaming remotely from the cloud).

It explores how playback technology changed the parameters of musical work at different moments in history: from two minutes of lo-fidelity mono sound on wax cylinder, to a streamed AI-composed remix that is unstoreable and infinite in length.

The pairing of *Build A Thing Of Beauty* and the SCI*FI*HI*FI is therefore intended to be not exactly a "concept album," but rather an experiment exploring the concept of albums as historical artefacts.

To listen to the album via the SCI*FI*HI*FI is to make sense of recorded music not as a fixed, frozen object but as an historical event unfolding over time. How was recorded music valued before the advent of albums, and how might it be valued after albums are gone?
FURTHER READING:


METHODOLOGY:

The methodology underpinning the research in this fanzine can be accessed here:
www.citizenbravo.com/