



UNIwersYTET JAGIELLOŃSKI  
W KRAKOWIE

FAENNS

Does pop music exist?  
Network structure in  
phonographic market.

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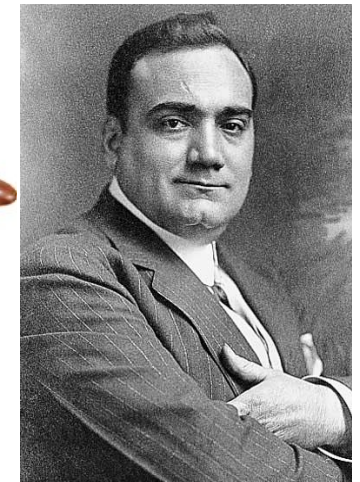
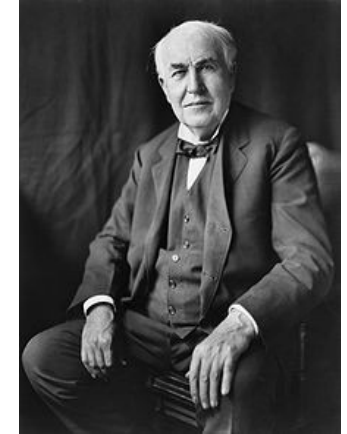


# 1. Introduction to phonographic market

**1887** Thomas Edison (1847-1931)  
The phonograph, record player, or gramophone is a device that was most commonly used from the late 1870s through the 1980s for playing sound recordings.

**1904** Enrico Caruso (1873-1921)  
was the first artist who sold over 1000000 records before The Beatles. He made approximately 290 commercial recordings of his voice, beginning as early as 1902 in Italy and continuing from 1904 until 1920 in the United States

**1948** Columbia released the first ever long playing record



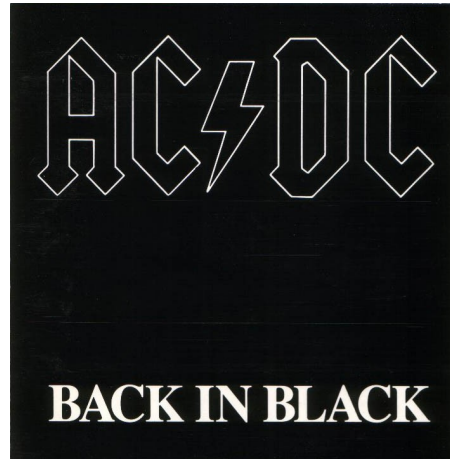
Library of Congress

1967 Since The Beatles' *Sgt Pepper's Lonely Hearts Club Band* long playing records (albums) has dominated the whole phonographic market. There are also new formats - CDs (1982) and mp3 (1990), etc.

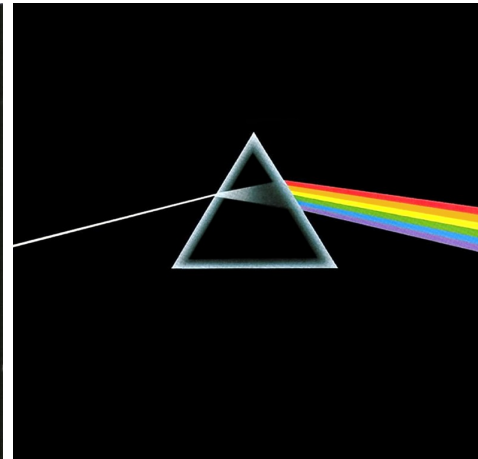
The best selling albums of all times are:



Michael Jackson – Thriller  
sold over 110,000,000 copies



AC/DC – Back In Black  
sold over 44,000,000 copies

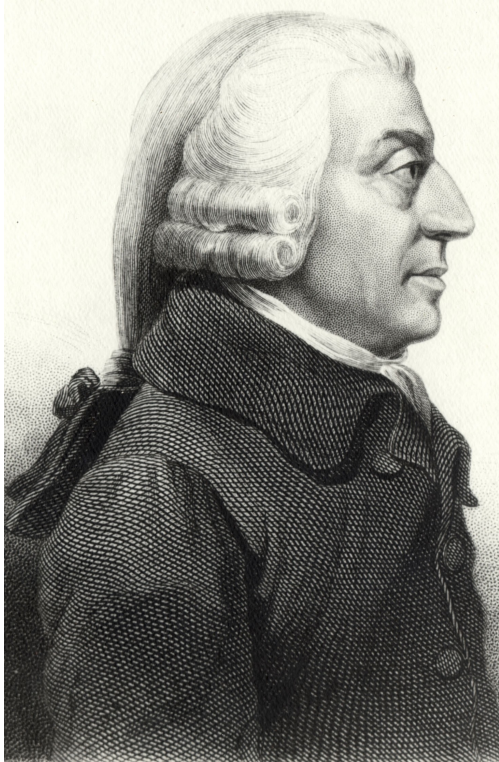


Pink Floyd – Dark Side Of The Moon  
sold over 43,000,000 copies



Mazowsze śpiewa kolędy  
Sings Christmas Carols  
sold over 1,000,000 copies

Global music sales in **2009** fell by 7% to US \$17 billion. This is disappointing, but amid the decline there are some very positive points. No fewer than thirteen countries saw music sales grow in 2009, including important markets such as Australia, Brazil, South Korea, Sweden and the UK. Digital sales in some of those markets rose at very encouraging rates, reflecting the new opportunities of online and mobile channels.



Important factors:

- marginal utility
- product lifecycle

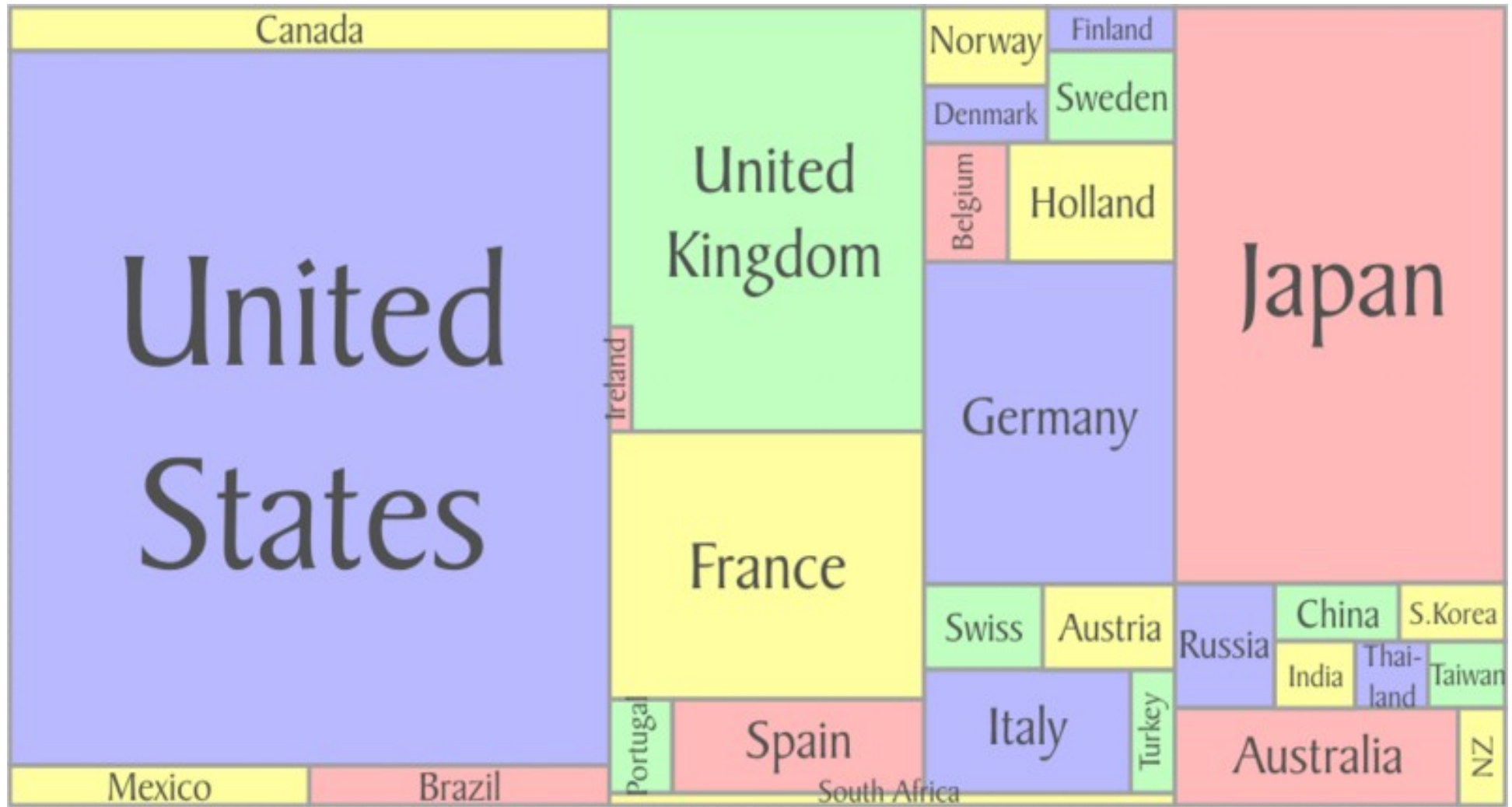
(especially in commodity markets)

80% of weekly record sales belongs to the four biggest record companies (Universal, EMI, Sony BMG and Warner Bros). All the world's most popular artists are signed to these companies. Thus, since 2003 it is possible to find their weekly record sales exactly.

The IFPI represents the recording industry worldwide, with a membership comprising some 1400 record companies in 66 countries and affiliated industry associations in 45 countries (USA, Japan, UK, France, Germany, Australia, Holland, Italy, Spain, Poland, etc.). China, India and Russia have small sales and are excluded because of piracy.



The phonographic market differs from financial and commodity markets because the price of a record (LP, CD, mp3) is constant. Therefore, the value of an artist is defined by the weekly record sales.



According to the IFPI more than 95% of the total revenue of music in 2003 was derived from the 30 major countries in the proportion shown above, organized by geographic location

## Financial market

stock prices

interest rate/price returns

correlation between stock prices

distance between stocks

life time of correlations between stocks

main indice portfolio

industry sectors and subsectors

## Phonographic market

weekly record sales

change of record sales

correlation between artists

distance between artists

life time of correlations between artists

top selling artists

music genres

## 2 The correlations

The correlation coefficient defines degree of similarity between the synchronous time evolution of a pair of assets.

$$\rho_{ij} = \frac{\langle Y_i Y_j \rangle - \langle Y_i \rangle \langle Y_j \rangle}{\sqrt{(\langle Y_i^2 \rangle - \langle Y_i \rangle^2)(\langle Y_j^2 \rangle - \langle Y_j \rangle^2)}}$$

$Y_i = \ln[P_i(t)] - \ln[P_i(t-1)]$  where  $P_i(t)$  is the weekly record sales of the artist  $i$  at the day  $t$ .

Let's introduce 3 levels of correlations given by:

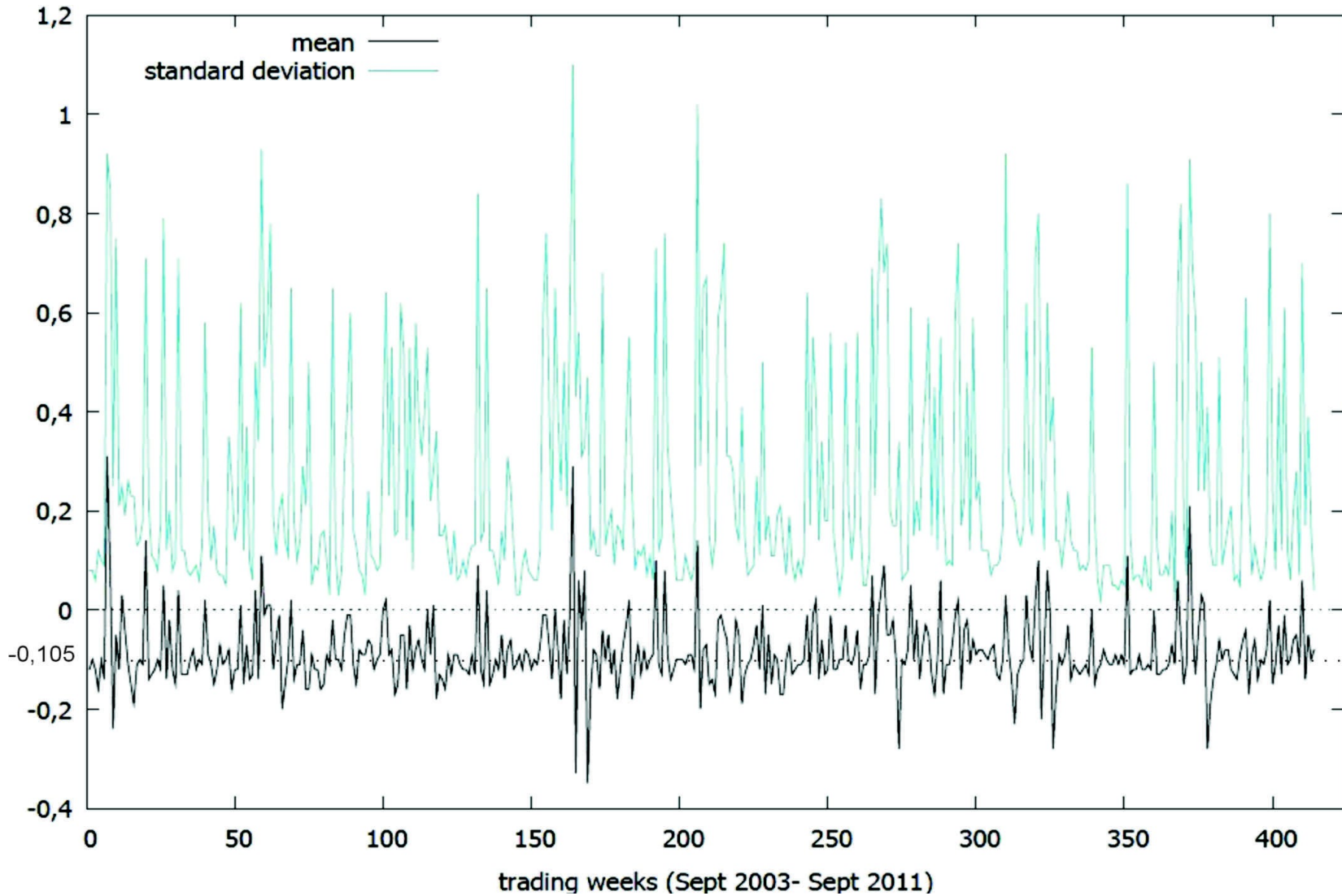
- |   |        |              |                    |
|---|--------|--------------|--------------------|
| 1.Strong (strongly correlated pair of stocks) | $\rho$ | $\mathbf{C}$ | $[\frac{1}{2}, 1]$ |
| 2.Weak (weakly correlated pair of stock)      | $\rho$ | $\mathbf{C}$ | $[0, \frac{1}{2})$ |
| 3.Negative (anti-correlated pair of stocks)   | $\rho$ | $\mathbf{C}$ | $[-1, 0)$          |

The correlation coefficient reflects the similarity between stocks. It can be used in building the hierarchical structure in financial markets and finding the taxonomy that allows to isolate groups of stocks that make sense from an economic point of view.

On the other hand, companies offering substitute products might be negatively correlated when they essentially compete over the same group of customers. Therefore, the success for one company often implies the failure for the others, indicating the market's reaction to the current situation (Furthermore, there is a fundamental negative correlation between gold-related stocks and the rest, indicating the complementary characters of these assets).

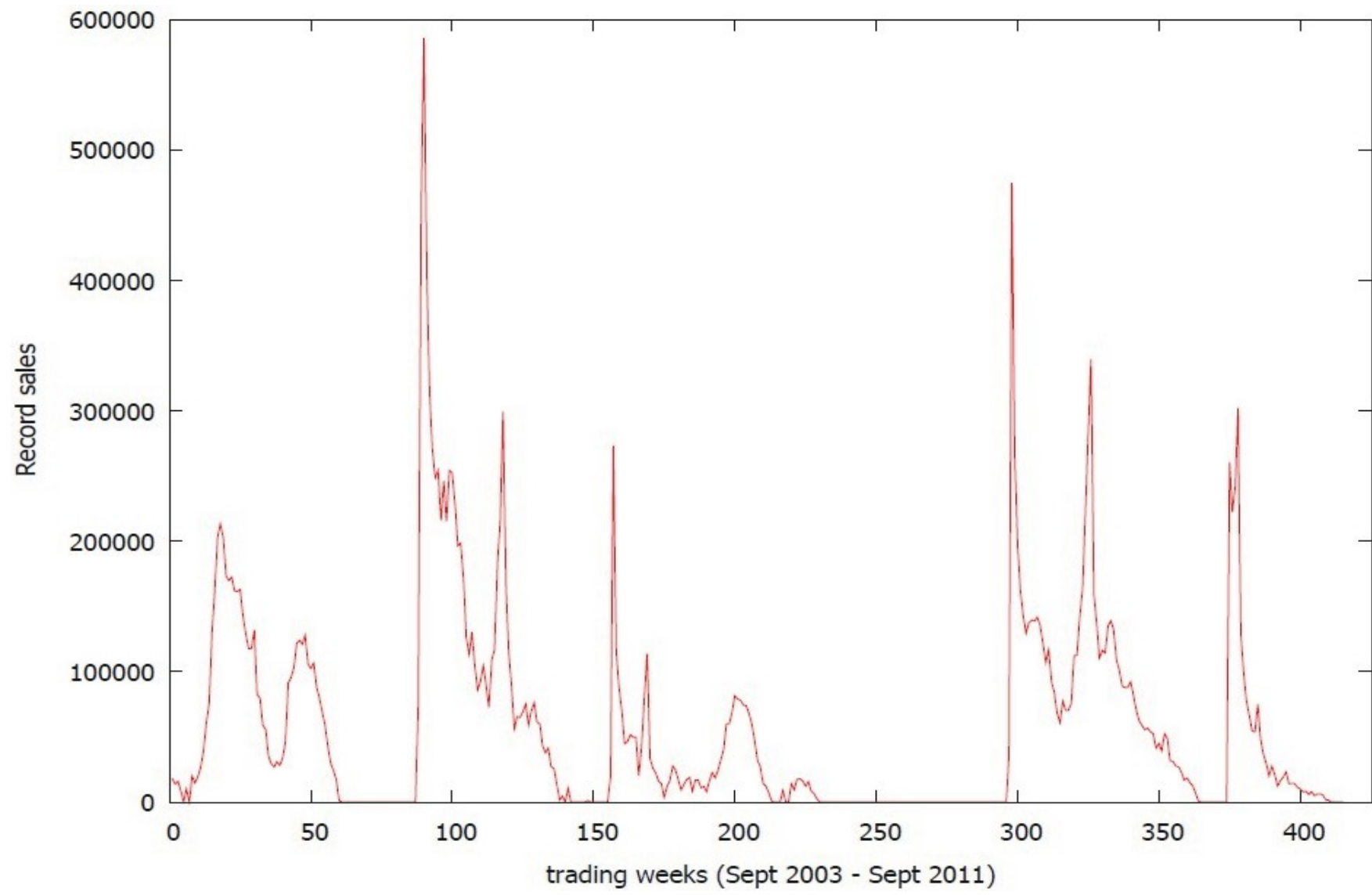
Correlated pairs	strongly	weakly	negatively
DJIA	9	426	0
DAX	205	119	1
WIG 20	1	188	1
Phonographic market	3	72	375





The mean logarithmic change of weekly record sales of the world's most popular 30 artists and the standard deviation (above) in the period 2003 to 2011



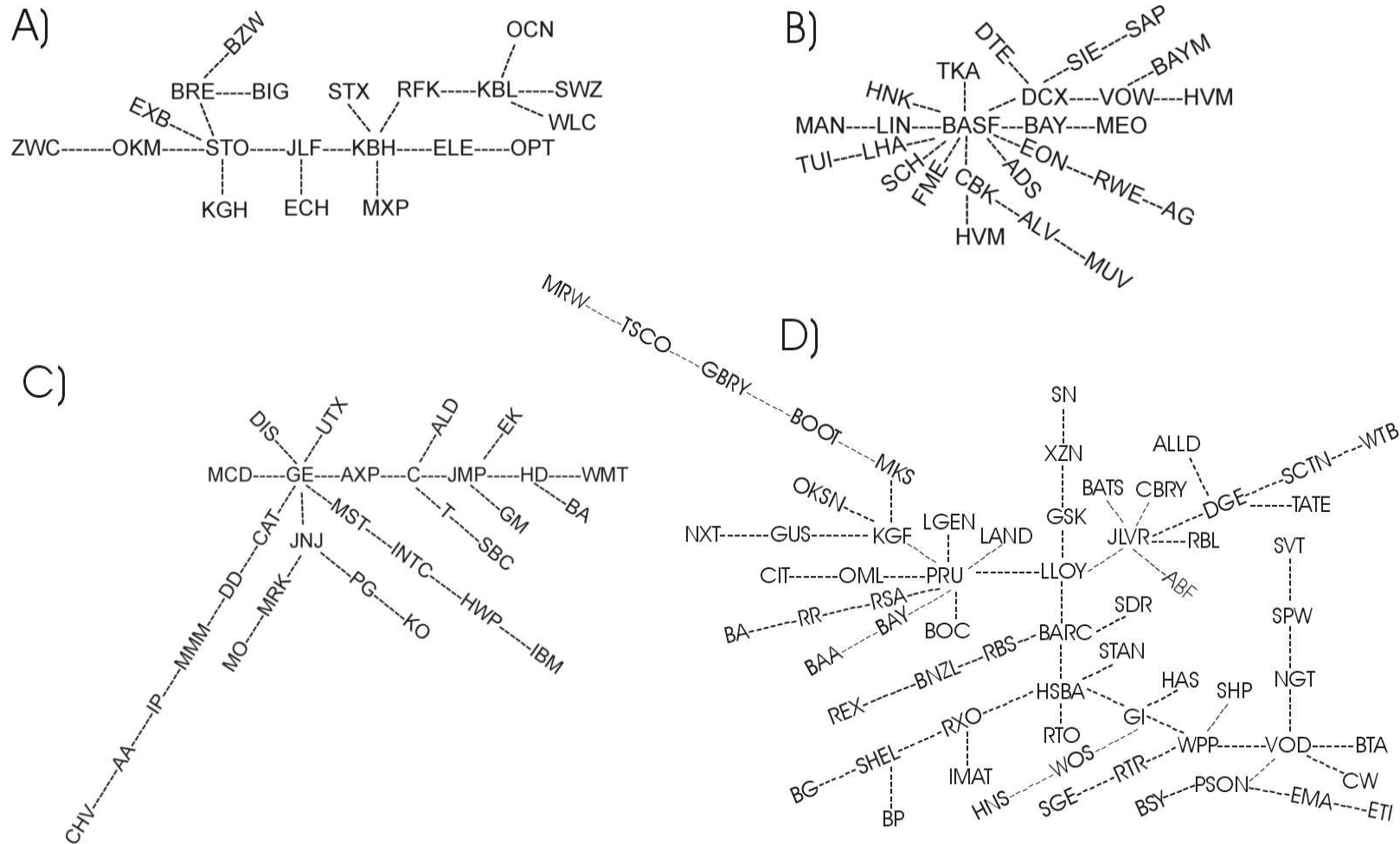


### 3. Distance between stocks (artists).

$$d_{ij} = \sqrt{2(1 - \rho_{ij})}$$

With this choice,  $d_{ij}$  fulfills three axioms of an Euclidean metric:

- (i)  $d_{ij} = 0$  if and only if  $i = j$ ,
- (ii)  $d_{ij} = d_{ji}$ ,
- (iii)  $d_{ij} < d_{ik} + d_{kj}$



**Fig. 1** Minimum Spanning Tree connecting the stocks used to compute  
 A) Warszawski Indeks Gieldowy (WIG 20) B) Deutsche Aktienindex (DAX)  
 C) Dow Jones Industrial Average (DJIA) D) FTSE 1000

The strongest correlated pairs in phonographic market are:

0.67 The Beatles – Jay-Z ( $d=0.81$ )

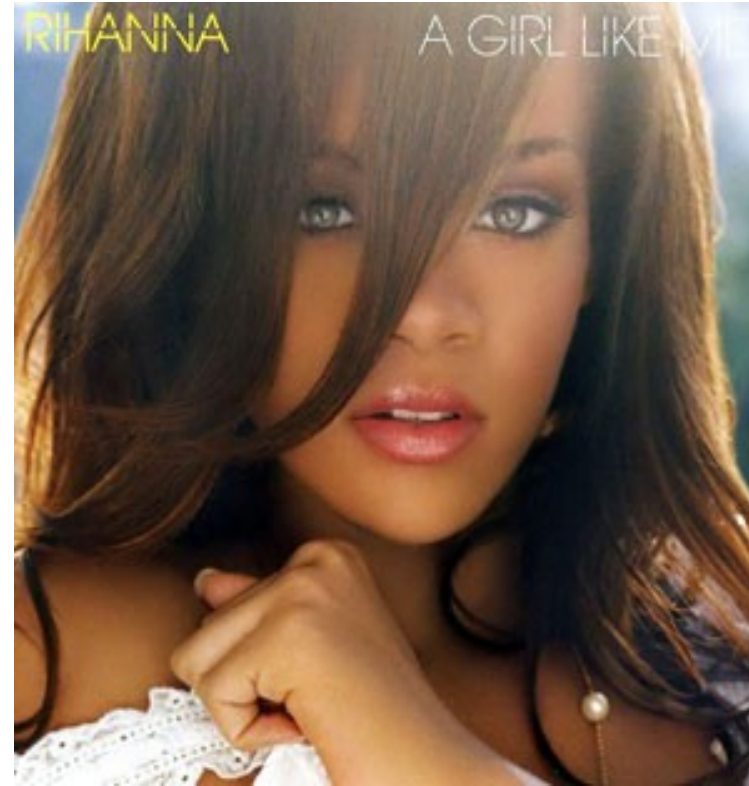
0.51 The Beatles – U2 ( $d=0.98$ )

0.50 Kanye West – 50 Cent ( $d=1$ )

**(2003-2011)**



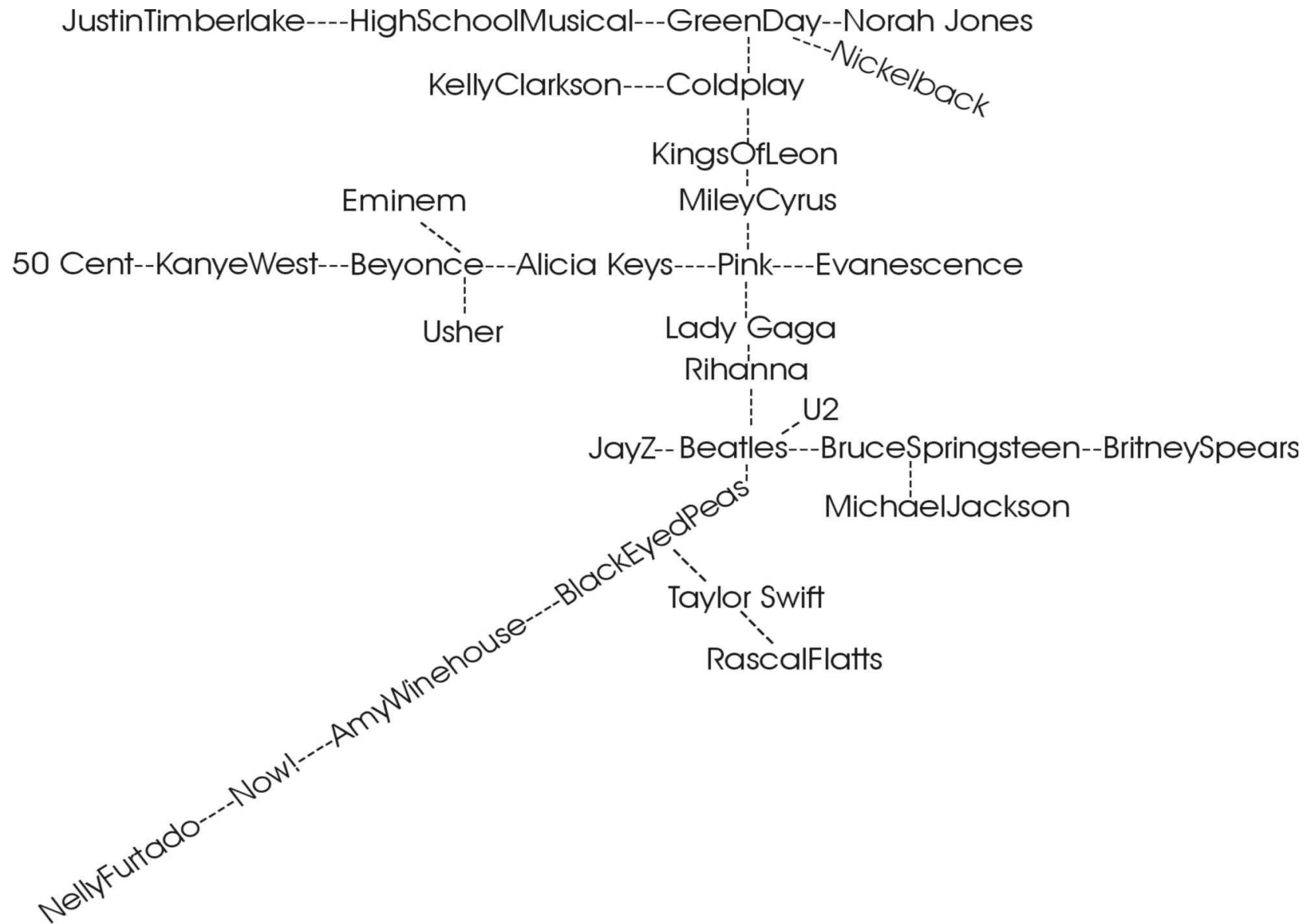
What do The Beatles and Jay-Z have in common ?



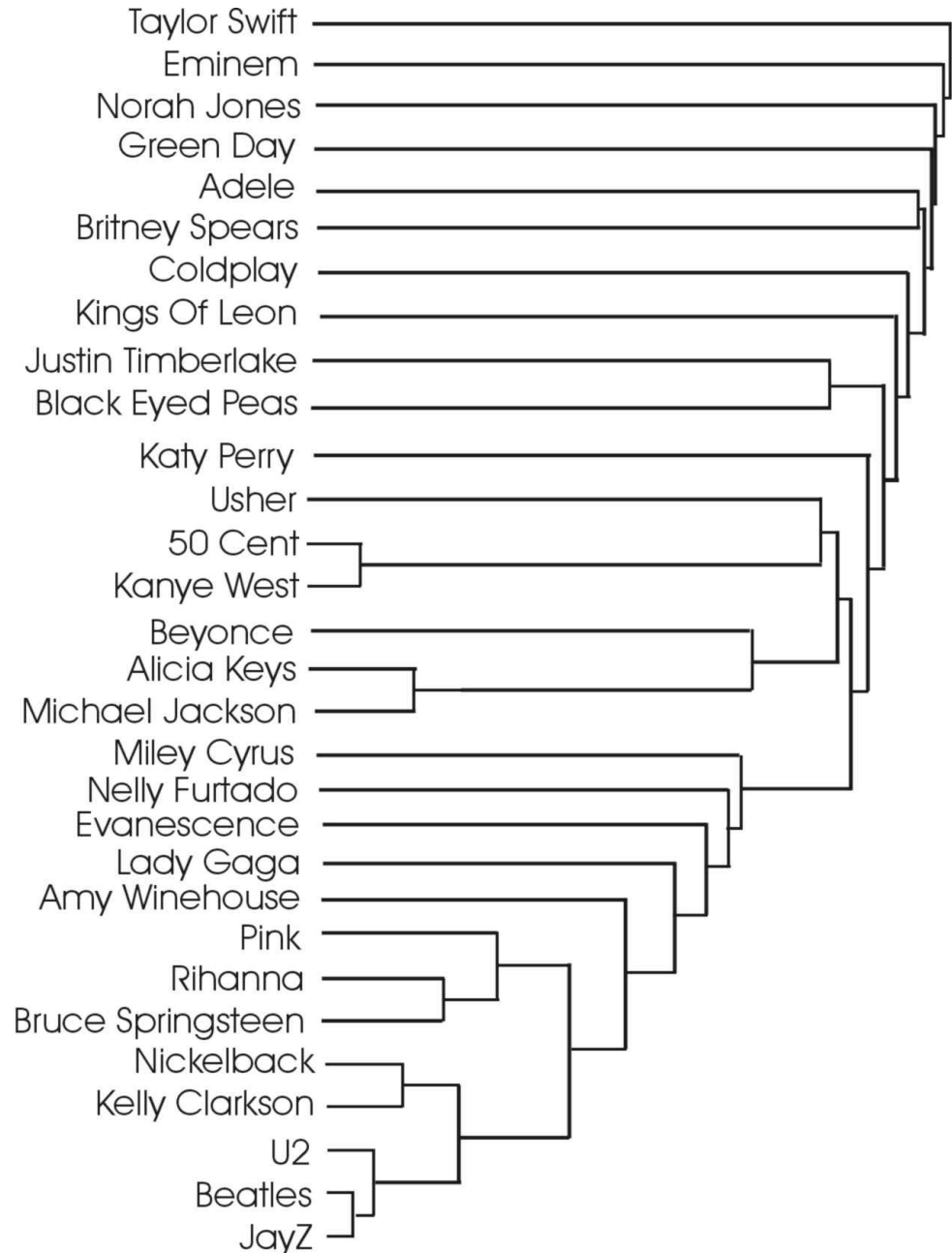
- 0.73 Lady Gaga – Rihanna (d = 0.73)
- 0.69 The Beatles – Jay-Z (d = 0.78)
- 0.61 The Beatles – U2 (d = 0.88)
- 0.58 Kanye West – 50 Cent (d = 0.91)
- 0.54 Jay-Z – U2 (d = 0.93)

**(2003-2010)**

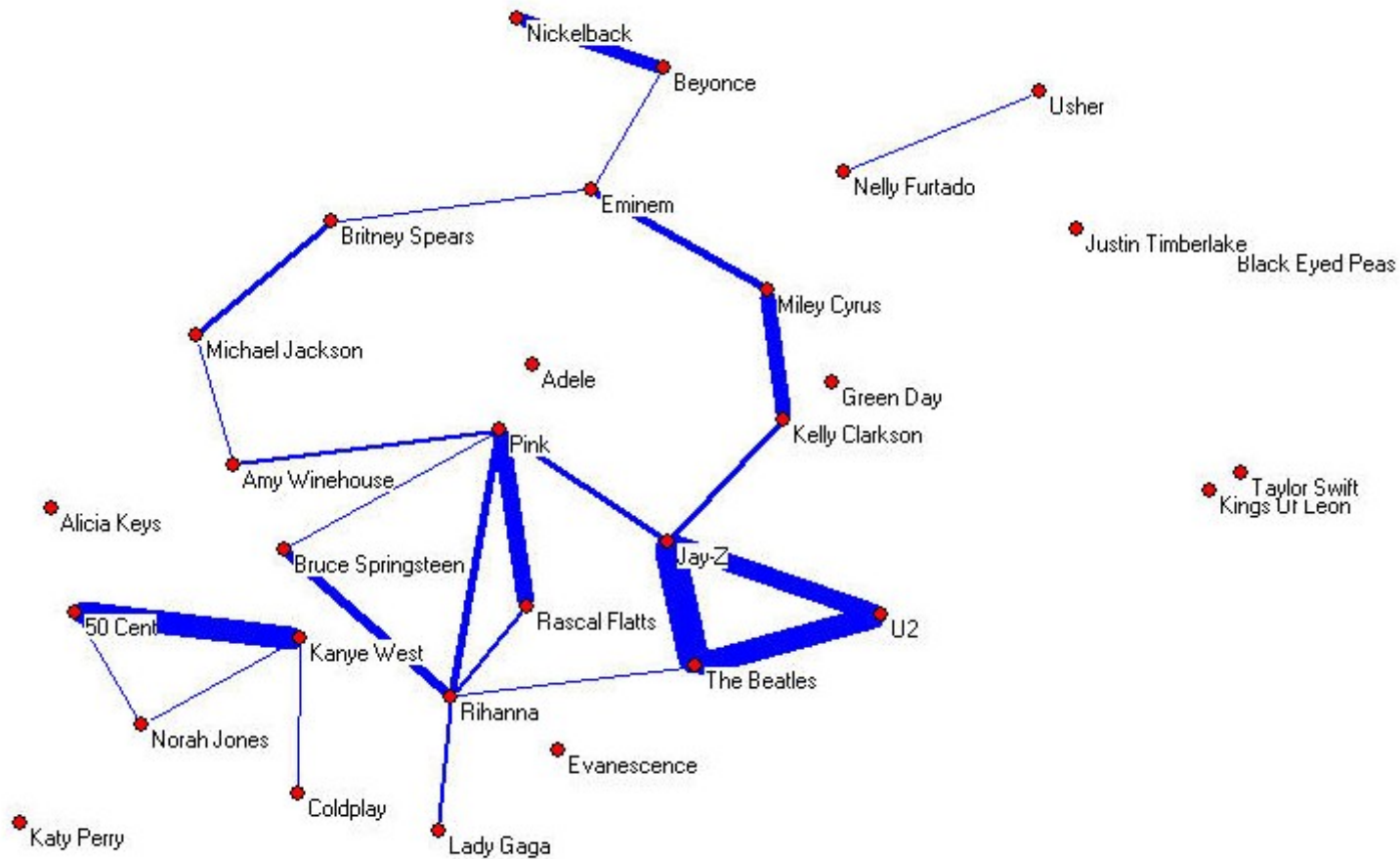




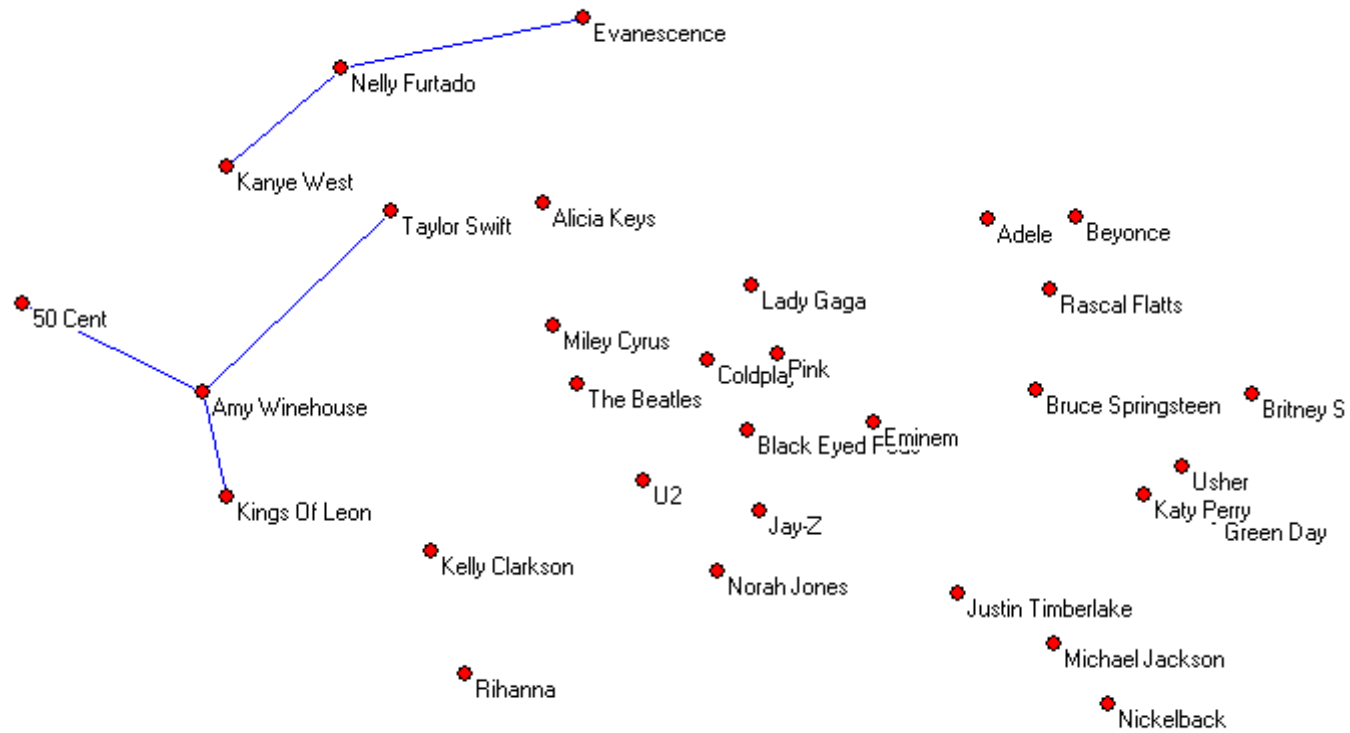
Minimal Spanning Tree connecting the world's most popular artists (2003-2010)



# 4 Networks

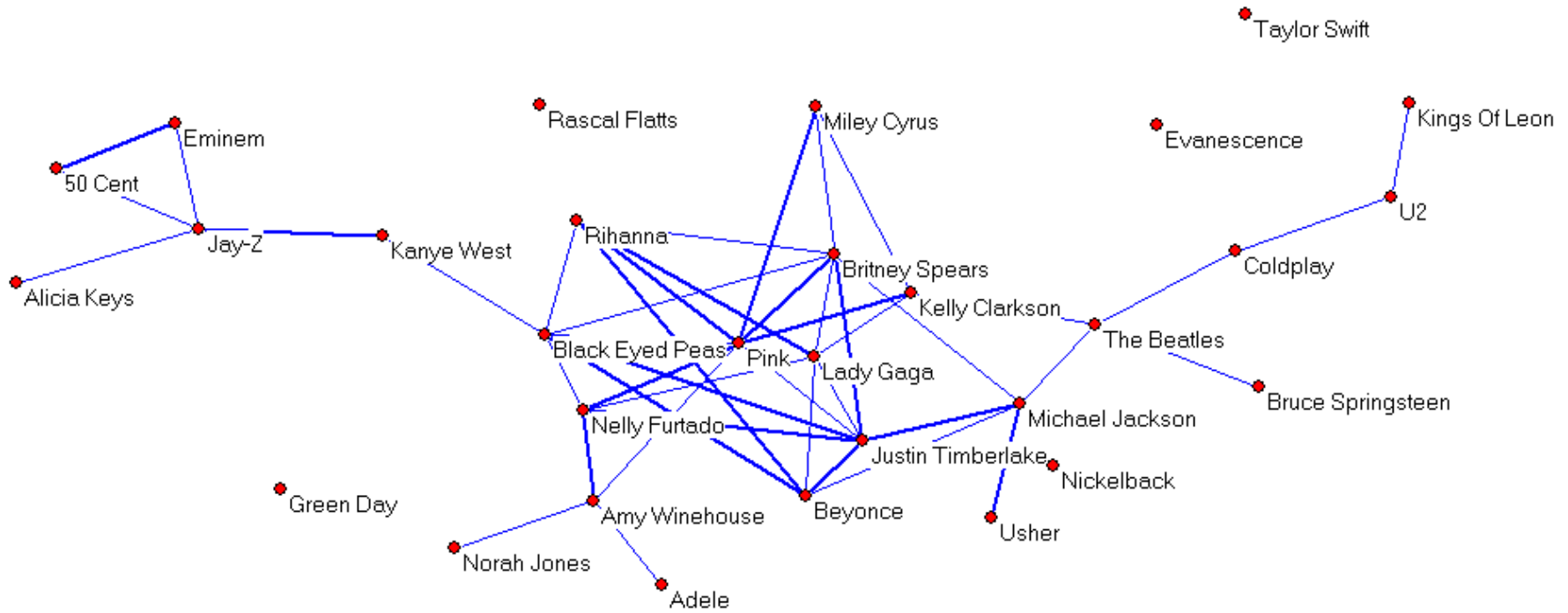


Positive correlations



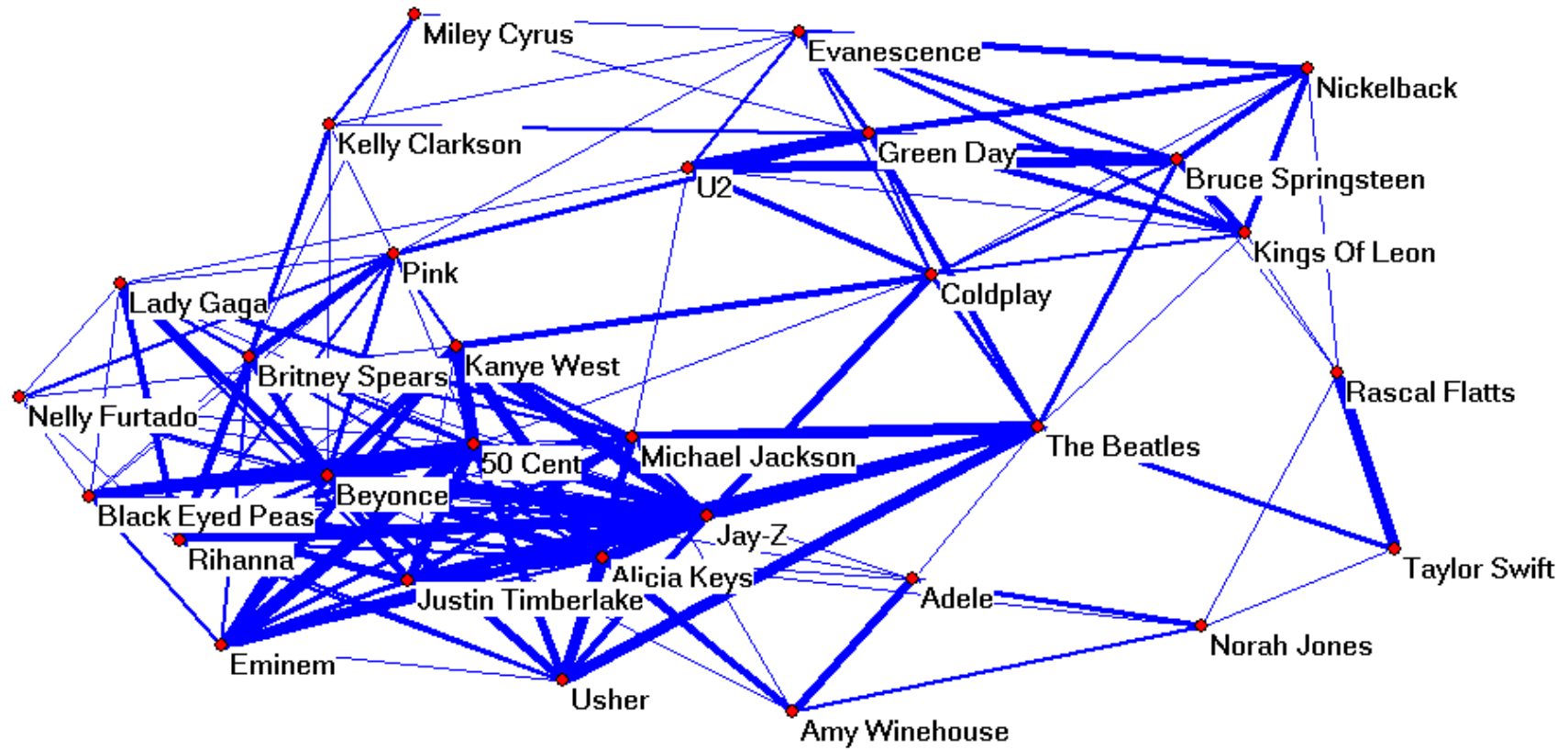
## Negative correlations

# Similarities



[All.music.com](http://All.music.com)

# Similarities



Expert – Andrzej Buda

Networks	ab	aj	av	all_music	market_corr	market_sq
ab	1.000000	0.419593	0.788389	0.338569	-0.013355	0.018541
aj	0.419593	1.000000	0.889206	0.357072	0.000759	-0.021621
av	0.788389	0.889206	1.000000	0.412641	-0.006217	-0.005308
all_music	0.338569	0.357072	0.412641	1.000000	0.023305	0.019327
market_corr	-0.013355	0.000759	-0.006217	0.023305	1.000000	0.926919
market_sq	0.018541	-0.021621	-0.005308	0.019327	0.926919	1.000000

**UK-SNA 2012, Bristol**

**Thank you for attention!**

**ArXiv,**

**<http://th.if.uj.edu.pl/~gulakov>**

