In [2]:
```
library(dplyr)
library(tidyverse)
library(ggplot2)
library(tsibble)
library(ggpubr)
```

In [3]:
```
options(scipen=999)
```

In [4]:
```
t1=rnorm(n=100,mean=50,sd=10)

t2=rnorm(n=100,mean=50,sd=30)
years=1901:2000

df=data.frame(year=years,t1=t1,t2=t2)


tsdf=df %>% as_tsibble(index=year)
```

GROWTH RATES

In [5]:
```
rates=tsdf %>% mutate(across(c("t1","t2"),function(x) difference(x)/lag(x)))

rates
```

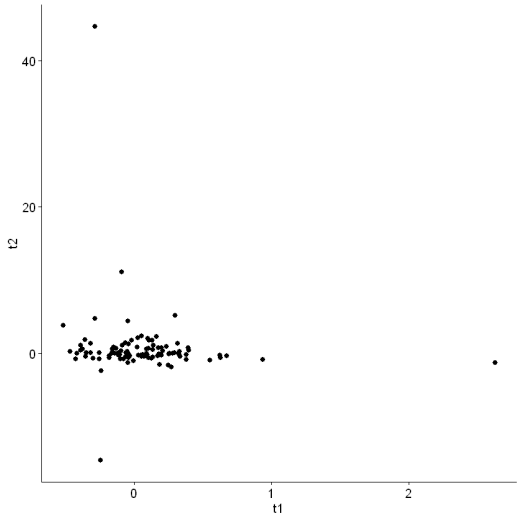
A tbl_ts: 100 × 3

year	t1	t2
<int>	<dbl>	<dbl>
1901	NA	NA
1902	0.05457620	-0.446929558
1903	0.32746400	-0.154449875
1904	-0.04593600	4.361296314
1905	-0.10117516	-0.188768982
1906	-0.29568146	-0.710900491
1907	0.20677320	0.314510529
1908	-0.51731795	3.820409150
1909	2.62870069	-1.300699978
1910	-0.23962907	-2.399326163
1911	-0.31447989	1.332850241
1912	0.19844421	-0.318632842
1913	0.08962194	-0.004598952
1914	-0.04572667	-1.285132186
1915	0.18420407	-1.541413384
1916	-0.28643000	4.721332464
1917	0.13712798	0.491654932
1918	0.18073169	-0.092431778
1919	-0.46565781	0.236235372
1920	0.38288389	-0.863955443
1921	0.29860677	5.151698647
1922	-0.13842654	-0.058517910
1923	0.32979311	0.218466808
1924	-0.25413802	-0.795533163
1925	0.02732721	2.078358672
1926	0.12533860	-0.685628362
1927	-0.31377324	0.012168159
1928	0.17871086	0.725695781
1929	0.28342464	-0.010665573
1930	0.05641424	2.377390876
...	...	...
1971	-0.06055122	1.43457557
1972	0.03059588	-0.25763386
1973	-0.06399394	-0.53748396
1974	-0.35524007	1.81098283
1975	0.67367281	-0.36794870
1976	0.25754576	-0.07495649
1977	-0.25377703	0.03350745
1978	-0.16169833	-0.01360266
1979	0.09228185	0.55173402
1980	-0.17803973	-0.64040925
1981	0.55494696	-0.97828498
1982	-0.28232648	44.67442046
1983	-0.15722903	0.01290370
1984	0.13100860	1.78217001
1985	0.04932008	-0.33587278
1986	0.02171549	0.77451366
1987	-0.17930710	-0.41012224
1988	-0.12857296	0.62847560
1989	0.62358888	-0.33138776
1990	-0.07730316	-0.76793812
1991	0.10981048	1.77386618
1992	0.13431921	-0.52135257
1993	-0.00459724	-1.08044603
1994	-0.24259805	-14.67283813
1995	0.16416421	2.25756716
1996	-0.11241146	-0.21758725

year	t1	t2
<int>	<dbl>	<dbl>
1997	0.10671337	0.62299284
1998	-0.11416386	-0.27318650
1999	0.19820870	0.71156368
2000	-0.03027759	-0.38989636

In [6]:
```
ggscatter(rates,"t1","t2")
```

```
Warning message:
"Removed 1 rows containing missing values (geom_point)."
```



Rolling functions

In [8]:
```
library(zoo)
```

In [10]:
```
# moving average 5

tsdf %>% rollapply(mean,width=5)
```

A matrix: 96 × 3 of type dbl

year	t1	t2
1903	51.36440	31.44002
1904	50.03983	29.46602
1905	49.74634	30.51948
1906	41.96603	46.13080
1907	45.83765	28.74985
1908	47.19597	26.51635
1909	47.93363	41.22271
1910	48.75729	49.45936
1911	54.96470	43.49253
1912	49.59461	45.47178
1913	49.72988	39.79484
1914	50.15323	32.76844
1915	50.14489	36.48671
1916	51.00716	38.81256
1917	47.08794	59.76956
1918	43.64562	60.32485
1919	46.07107	64.53043
1920	45.84318	62.71459
1921	46.96575	65.37020
1922	50.19163	51.25071
1923	51.36021	59.47689
1924	51.22943	48.11145
1925	49.23962	37.64701
1926	45.48368	26.60987
1927	47.33710	28.92852
1928	49.56443	37.79077
1929	49.30018	47.90572
1930	54.17632	52.64550
1931	57.15704	56.94574
1932	53.65067	62.12535
...	...	...
1969	50.73544	47.32327
1970	49.48202	46.82216
1971	52.65498	39.46091
1972	50.33387	66.65751
1973	50.08132	70.49499
1974	53.40411	62.10532
1975	52.82628	59.04076
1976	51.25929	63.50680
1977	54.18903	62.11114
1978	50.90182	56.54550
1979	49.11882	45.81335
1980	47.43741	40.71355
1981	46.06729	35.84563
1982	44.85864	35.93268
1983	45.77682	41.22536
1984	42.50000	61.45180
1985	41.07697	67.33140
1986	40.08967	80.68008
1987	42.14857	76.48041
1988	42.98368	68.04115
1989	44.68771	56.09830
1990	49.44775	48.11716
1991	55.10306	28.23455
1992	53.80230	19.58929
1993	54.81542	30.99141
1994	53.56848	33.86915
1995	51.89259	48.17257

year	t1	t2
1996	49.07591	61.82107
1997	51.03563	80.19480
1998	51.15373	79.67171

In [11]:
```
#5 year period averages
tsdf %>% rollapply(mean,width=5,by=5)
```

A matrix: 20 × 3 of type dbl

year	t1	t2
1903	51.36440	31.44002
1908	47.19597	26.51635
1913	49.72988	39.79484
1918	43.64562	60.32485
1923	51.36021	59.47689
1928	49.56443	37.79077
1933	52.42961	50.90201
1938	54.91957	57.36907
1943	47.87407	39.40731
1948	50.16708	44.67407
1953	49.75630	63.27801
1958	51.75992	36.42534
1963	50.03605	44.96668
1968	53.09496	41.75494
1973	50.08132	70.49499
1978	50.90182	56.54550
1983	45.77682	41.22536
1988	42.98368	68.04115
1993	54.81542	30.99141
1998	51.15373	79.67171

In [ ]:
```

```