LONG WAVES IN WORLD INDUSTRIAL PRODUCTION, ENERGY CONSUMPTION, INNOVATIONS, INVENTIONS, AND PATENTS AND THEIR IDENTIFICATION BY SPECTRAL ANALYSIS

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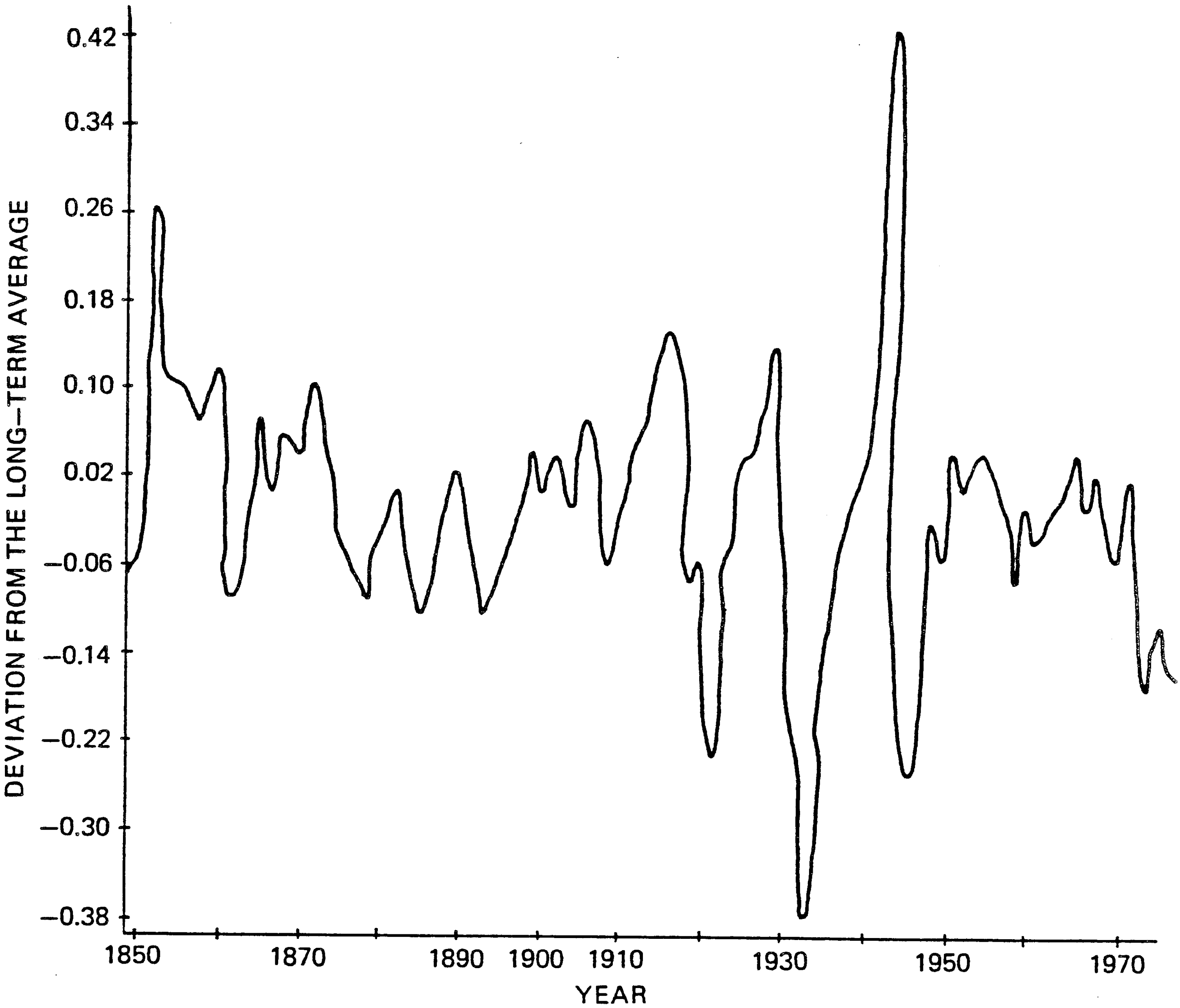
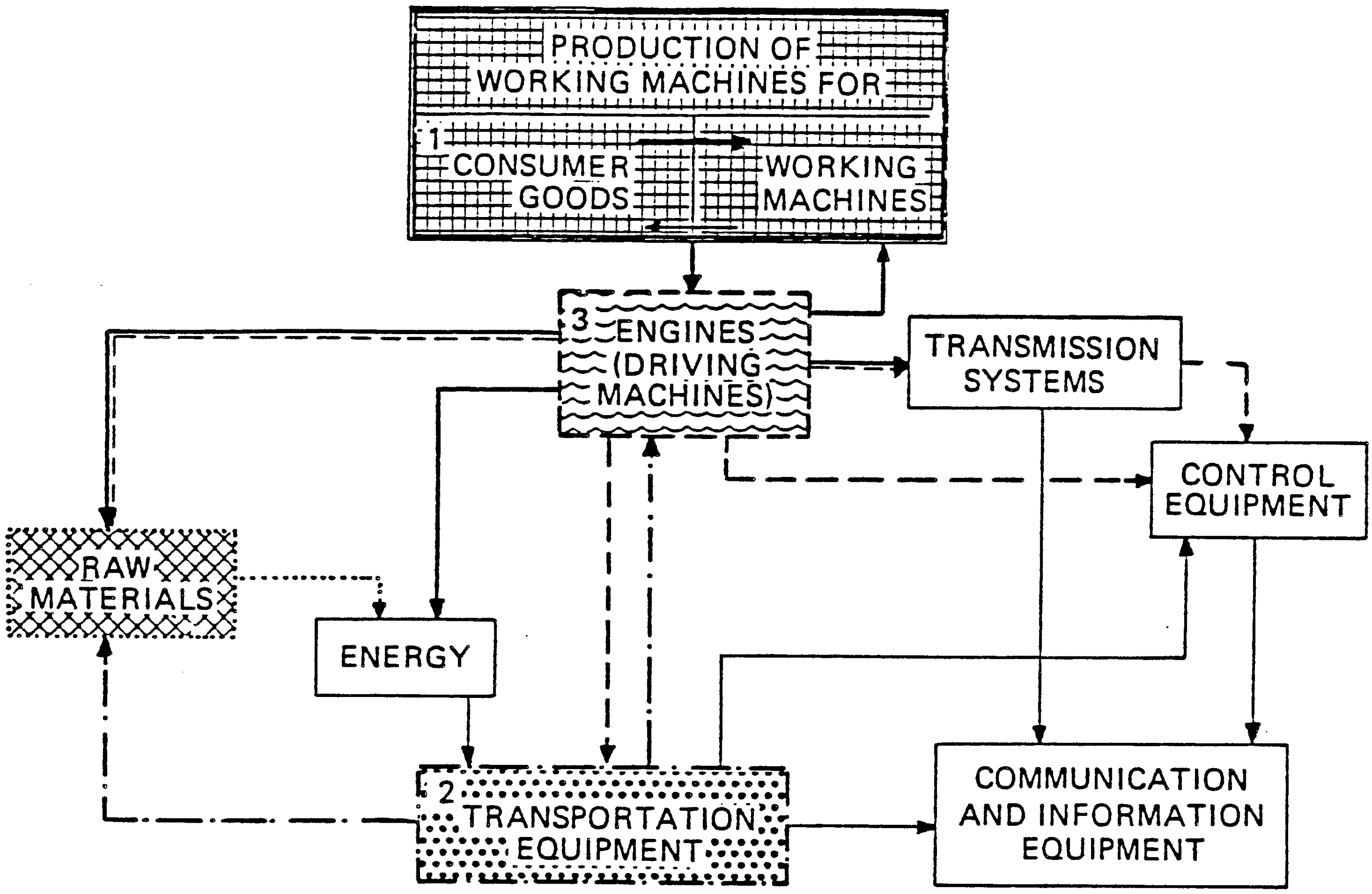


Figure 1. World industrial production logarithm (1850-1979).

PRODUCTION OF PRODUCTION GOODS



PRODUCTION OF CONSUMER GOODS

Figure 2. The two production sectors and their inner feedbacks.

CHAPTER 3

THE DATA

The data used are presented in Appendix 1. For world industrial production, we used the data collected by Juergen Kuczyuski (1967) and Thomas Kuczynski (1978) for the period 1850-1976 and completed them by using the Hoffmann Index (Hoffmann 1955) for the period 1740-1849 and UN Statistics (Monthly Bulletin 1975-1981) for the last years.

Data on world primary energy consumption are available from 1850 (Schilling, Hildebrandt 1977). Further, data on patents granted in England and in the US are presented in Mitchell (1975) and Technology Assessment and Forecast (1977). Data on English patents between 1700 and 1890 might best represent world technological progress, followed by US patents from 1890 to the present.

We collected data on 182 inventions and innovations, including the list of 90 inventions and innovations used by Gerhard Mensch (1975), and calculated the following indicators (see Apppendix II):

t_L = the date of invention according to the date
of the first major patent application or other sources

t_E = the date of innovation, normally the date of
first production or market introduction

T_E = the time period between invention and innovation
($= t_E - t_L$), also called "lead"

v_E = the speed of innovation ($=100/T_E$)
The earlier an invention is realized as an
innovation, the higher this indicator will be.

V_K = the range of application of a given innovation

i_K = the scientific-technological level of a given innovation. V_K and i_K are explained in Table 4.
w_K = the coefficient of importance (= $i_K \cdot V_K$)
p = the innovation potential (= w_K / T_E).
p* = the innovation power ($= p \cdot v_E = w_K^2 / T_E$)

The dates of invention and innovations, taken from historical sources, determine t_c, t_E and T_E.

The coefficients i_k and V_k were calculated on the basis of Table 8. We used 7 levels for each indicator and evaluated them quantitatively. The main assumption here was the existence of an exponential frequency distribution of different classes of innovations (Haustein, Maier, and Uhlmann 1981).

If we assume that the importance of innovations w (a coefficient between 1 and 100) follows an exponential function and the parameters i_k and u_k are connected in a multiplicative form, we can write

$$w = i_k V_k$$
$$w = e^{ak} e^{bk}$$

and

$$w = e^{(a+b)k}$$

Taking a simple symmetrical scheme ($a = b$), we then have

$$w = e^{2ak}$$

where

$$k = 0,1,\ldots,6.$$

According to $1 < w \leq 100$ (percent), we find for k = 6

$$100 = e^{12a}$$
$$a = \ln\frac{100}{12} = 0.38376$$

From this we find the coefficients of importance for each level within the 7 x 7 = 49 field (see Table 8).

When we try to adjoin one innovation to the 7 x 7 = 49 field, we realize that we often have difficulty in making an exact estimation. So it is clear that the invention and innovation indicators are by no means exact figures.

Each of the inventions and innovations is represented by three indicators:

- number
- coefficient of importance w

- power coefficient p*

These indicators are calculated according to the data on 182 inventions and innovations contained in Appendix II. We think that the coefficient of importance better represents the real weight of an innovation or invention than does their simple number. The definition of the innovation potential $p = i\frac{V}{T}$ seems to be analogous to the physical definition of energy. The higher the innovation potential, the shorter the lead and the bigger the importance of the innovation. It can be assumed that the diffusion of such innovations will then also be quicker. The power coefficient is the potential coefficient weighted by the importance coefficient.