The circular relationship between productivity and hours worked: A long-term analysis

Gilbert Cette
Simon Drapala
Jimmy Lopez

Outline

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1. Introduction

- **Over a long period, in advanced countries**
  - ***TFP* and labor productivity** per hour (*LP*) have both greatly improved
  - **Average annual hours** worked per employee (*H*) have fallen dramatically
  - **Annual average wage** (*W*) has risen dramatically
- **A *TFP* and *LP* increase may impact *H* through two channels** (see Boppart & Krusell, 2020)
  - **Income channel** (*H* decreases when *TFP* and *LP* increase)
  - **Substitution channel** (*H* increases)
- **Abundant empirical literature**
  - Income channel dominates, see Li (2022) …
  - Substitution channel dominates, see Reif *et al.* (2021) …
  - The order of precedence between the two channels depends on other factors, as the level of development, see Boppart & Krussel (2020); Bick *et al.* (2018) and (2022b); …

1. Introduction

- **In the same time *H* could itself impact *TFP* and *LP* through two channels**
  - **A fatigue effect** (*TFP* and *LP* increase when *H* decreases)
  - **A fixed-cost or learning-by-doing effect** (*TFP* and *LP* decrease)
- **Abundant empirical literature**
  - Fatigue effect dominates, see Bourlès & Cette (2007); Aghion *et al.* (2009); Pencavel (2015); …
  - The order of precedence between the two channels depends on numerous factors, as *H* itself (see Bick *et al.,* 2022a), the number and the position of the vacation days in the week and the year (see Eden, 2021); …
  - Increasing returns for short hours and decreasing for long hours, see Bick *et al.* (2022a); …

1. Introduction

- **Aim of the paper**: to estimate this circular relationship
  - From *LP* (or *W*) to *H*
  - From *H* to *LP*
- **Originalities of the paper**
  - A theoretical model
  - Estimates (OLS and IV methods) a circular relationship between productivity (*LP*) and hours (*H*)
  - Estimates on two original datasets:
    - Very long-term (1891-2019) productivity panel database on 21 advanced countries
    - Industry level panel database on a recent period (1995-2019) and on 22 advanced countries
  - Distinguish income channel and substitution channel

2. Theoretical model

- **Assume a CES utility function**:

  (1) $\boldsymbol{U = [(1-\lambda)L^{\frac{\rho-1}{\rho}} + \lambda R^{\frac{\rho-1}{\rho}}]^{\frac{\rho}{\rho-1}}}$ with $0 < \lambda < 1$

  U: utility level; L: leasure; R: labor income

  ρ: substitution elasticity between L and R, with $\rho > 0$

- (2) $\boldsymbol{L = D - H}$

  with D: global time budget; H: hours worked

- (3) $\boldsymbol{R = A\, e^{\gamma t} H^{\beta}}$ with $\gamma, \beta > 0$

  γt: impact of the technical progress; β: returns to scale of working hours H

- From that we get:

  (4) $\boldsymbol{H^{\beta(\rho-1)-\rho}(D-H) = \left(\frac{1-\lambda}{\lambda\beta}\right)^{\rho} A e^{(1-\rho)\gamma t}}$

  $\Rightarrow$ H decreases with γ if $\rho < 1$: the income channel dominates

  $\Rightarrow$ H increases with γ if $\rho > 1$: the substitution channel dominates

2. Theoretical model

- **In the particular case where $\rho = 1$**, then:

  (5) $\boldsymbol{H = \frac{\lambda\beta}{\lambda\beta+(1-\lambda)} D}$

  H is constant and does not depend on productivity gains *γ*

- And **in the more specific case where $\beta = 1$**, then:

  (6) $\boldsymbol{H = \lambda D}$

  the level of *H* is a simple constant share of *D*

3. Estimated models

- **Two types of relations are estimated**
  - **From productivity to hours**

(7) $$\boldsymbol{log(H) = a1.log(LP) + a2.\Delta log(LP) + a3.log(LP).\Delta log(LP) + \Sigma_i(c_i.CV_i) + \Sigma_j(d_j.FE_j) + u}$$

with *H*: average working time; *LP*: labor productivity per hour; CV_i: control variables; FE_j fixed effects; *u*: error term

- *CV*: employment rate and tax rate (social and income)
- FE_j: country and year fixed effects, and country*year and industry*year fixed effects on the country*industry*year dataset
- *a1*: long term effect with:
  a1 > 1 => the substitution channel dominates the income channel
  a1 < 1 => the income channel dominates the substitution channel
- *a2, a3*: short term effect

3. Estimated models

- **Two types of relations are estimated**
  - **From hours to productivity**

    (8) $\boldsymbol{log(LP) = b1.log(H) + \Sigma_i(c_i.CV_i) + \Sigma_j(d_j.FE_j) + u}$

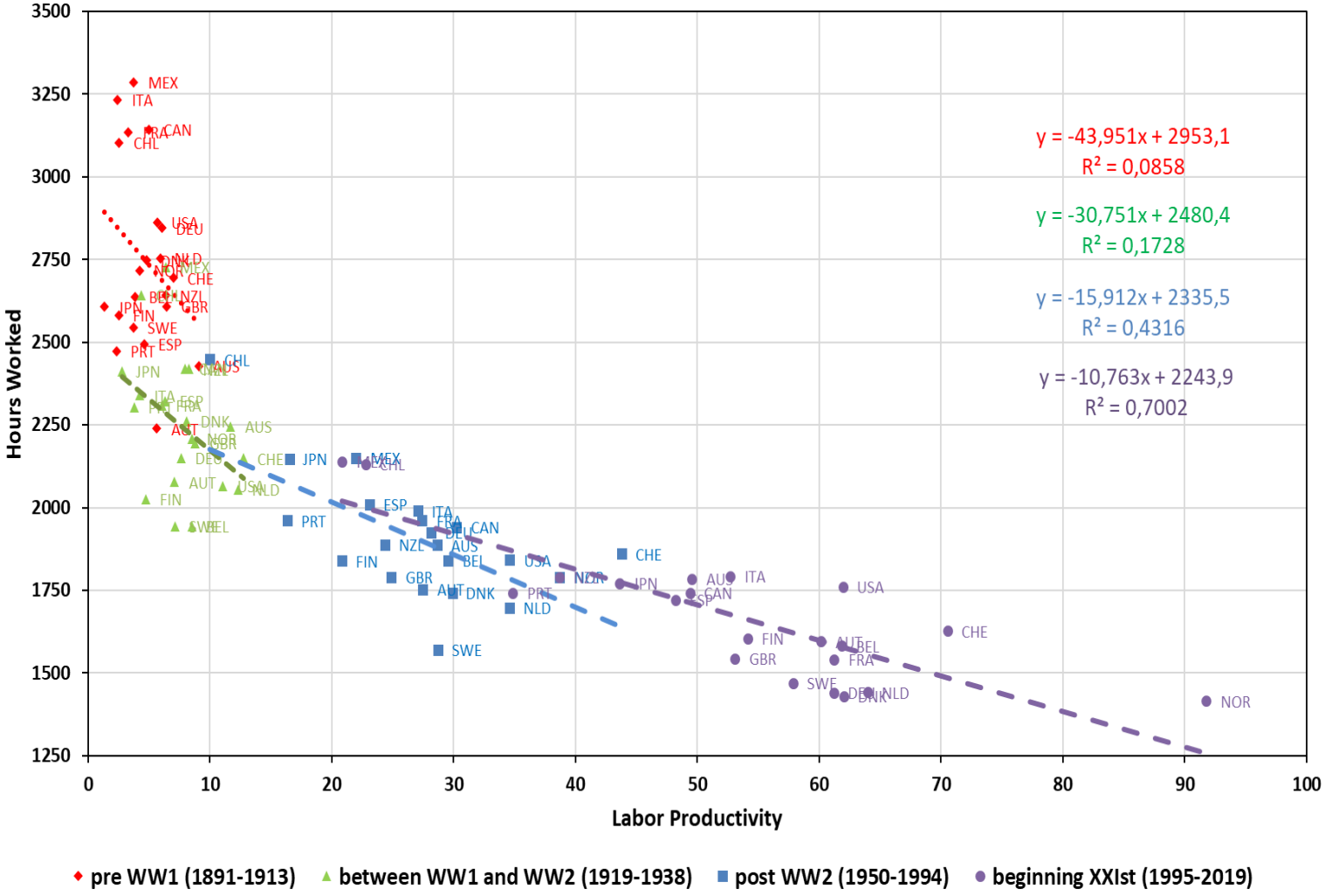
    - *LP* replaced by *W* (average wage) on the country*industry*year dataset
    - *CV*: employment rate and capital to hours worked ratio
    - FE_j: country and year fixed effects, and country*year and industry*year fixed effects on the country*industry*year dataset
    - *b1*: long term effect

4. Data

- **Two dataset**
  - **Country*year dataset**
    - Source: Bergeaud, Cette & Lecat (2016), long-term productivity database
    - 21 advanced countries
    - Period: 1891-2019 except 1914-1918 and 1939-1949
    - *H* and *LP* smoothed with HP filter
  - **Country*industry*year database**
    - Source: from EU KLEMS and INTANProd
    - 21 advanced countries
    - 23 business sector industries
    - Period: 1995-2019

4. Data

- **Chart 1 - Hours Worked and Labor Productivity – Country averages (21) over for four sub-periods Country level database**

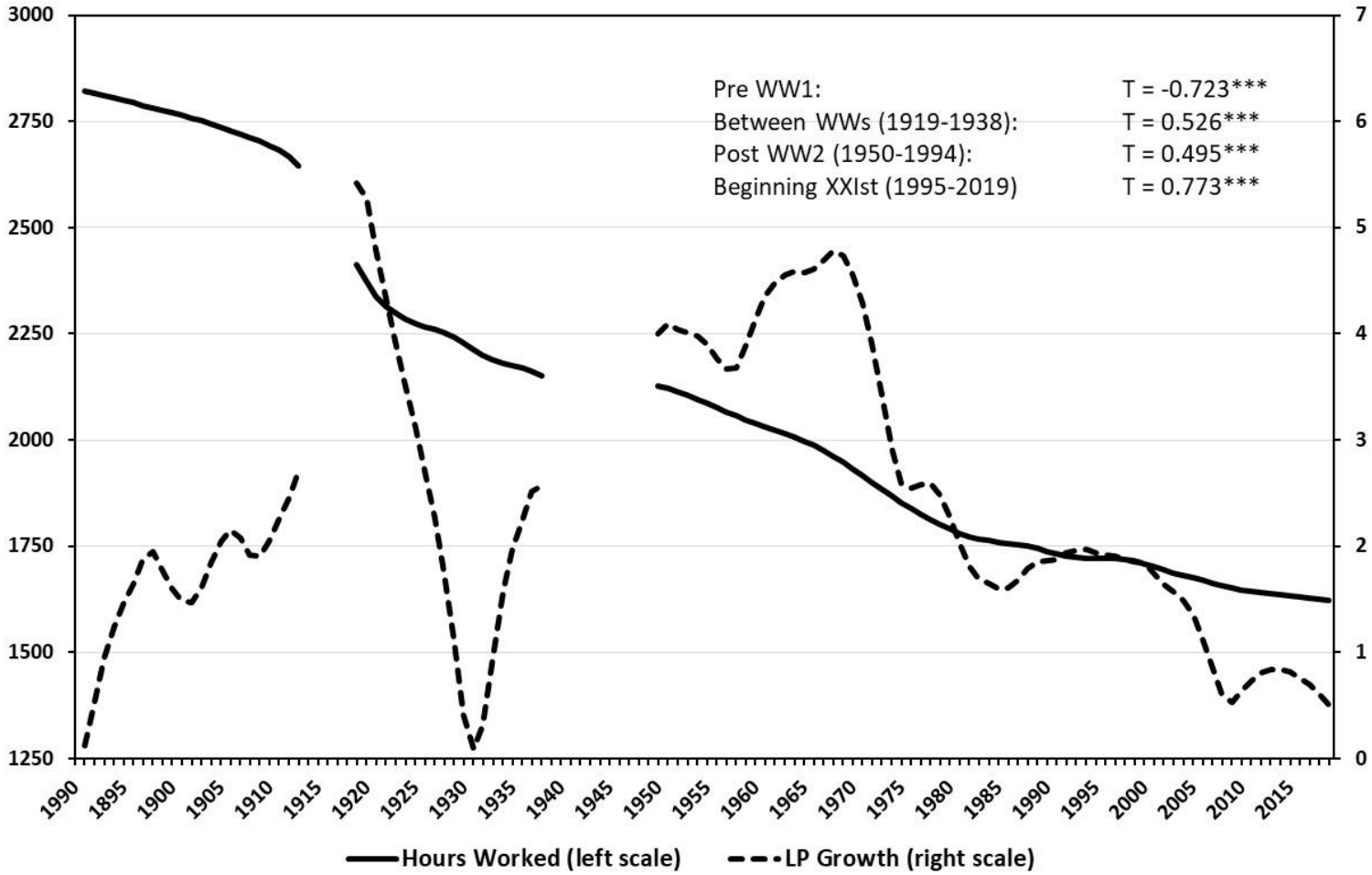


Each point represents a specific country average for one sub-period

- Income channel dominates on the long run

4. Data

- **Chart 2 - Hours Worked and Labor Productivity Growth – Yearly averages Country level database**

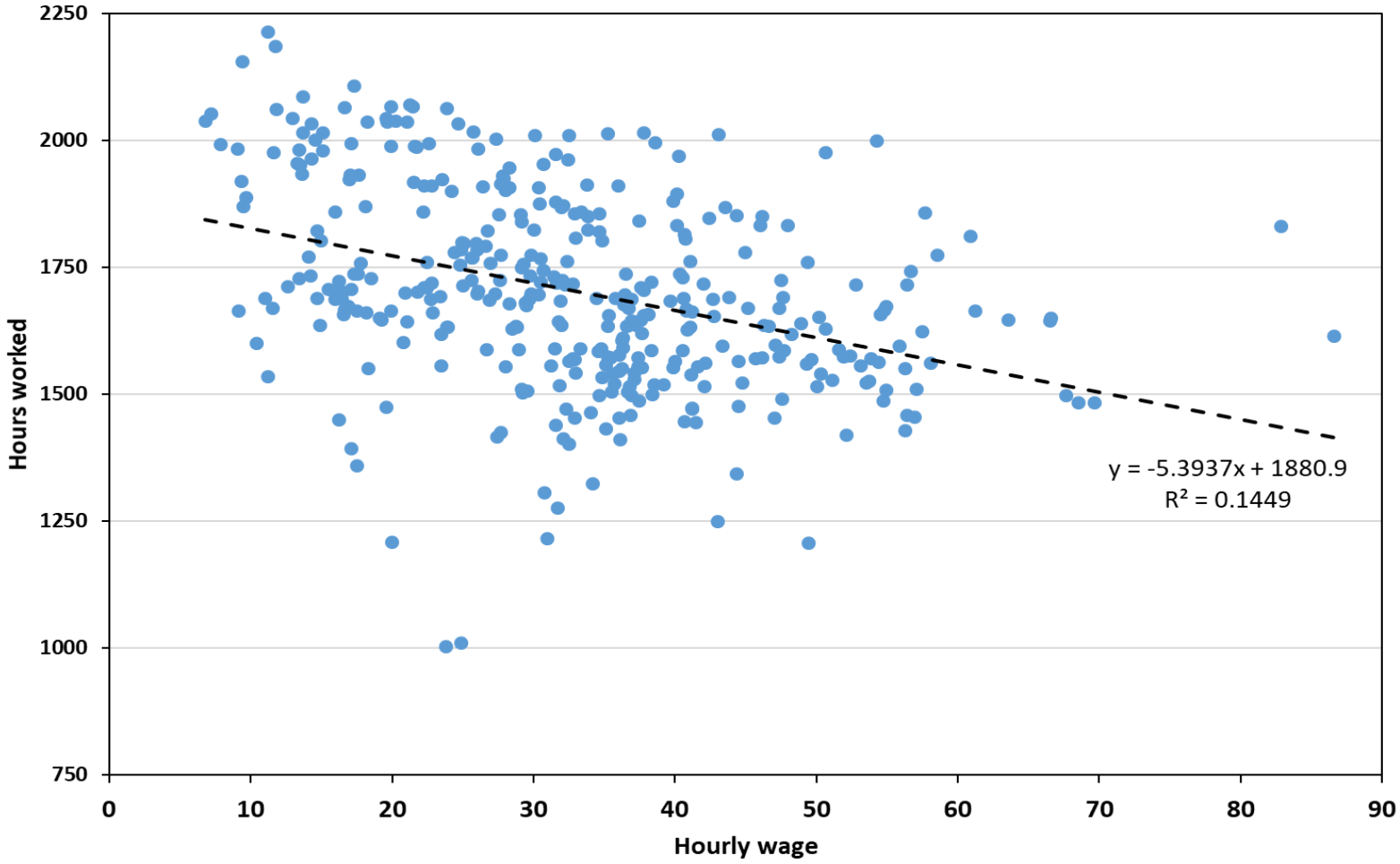


Each point represents the annual sample average of the values taken by labor productivity growth and hours worked

- Income channel or substitution channel dominates on the short run, depending on the sub-period

4. Data

- **Chart 3 - Hours Worked and Hourly Wage, country*industry average, period 1995-2019 Industry level database**



Each point represents a country-industry specific average on the 1995-2019 period

- Income channel dominates on the medium run

5. Estimate results

➢ **Table 1 - Impact of productivity on hours, OLS estimates - Country level database**
Dependent variable: Hours worked per worker (in log)

	(1)	(2)	(3)	(4)	(5)	(6)
Period	1963-2006	1950-2019	1950-2019	1950-2019	1950-2019	1950-2018
Country Sample	15	15	21	21	21	15
$\log(LP)$				-0.138***	-0.157***	-0.152***
				(0.008)	(0.007)	(0.022)
$\Delta \log(LP)$	1.284***	1.145***	0.581***		0.823***	1.074***
	(0.163)	(0.185)	(0.120)		(0.113)	(0.169)
$\Delta \log(LP) * \log(LP)$					1.449***	1.575***
					(0.139)	(0.218)
Labor Income Tax Rate						-0.292***
						(0.041)
Employment Rate						-0.412***
						(0.084)
R^2	0.899	0.882	0.889	0.920	0.928	0.908
Observations	660	1050	1470	1449	1449	1010

- Consistent with Reif *et al.* (2021) results: substitution channel dominates in the short run
- Income channel dominates in the long run
- Substitution channel dominates in the short run
- Negative impact of tax rate (substitution channel), consistent with Prescott (2004), Ohanian *et al.*, (2008), Reif *et al*. (2021)

5. Estimate results

➢ **Table 2 - Impact of Productivity on hours, IV estimates**
Dependent variable: Hours worked per worker (log)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Sample	Country level						Industry level[(a)]
Period	1891-1913	1919-1938	1950-1994	1995-2019	1950-2019	1891-2019	1995-2019
$\log(LP)$	-0.231***	-0.342***	-0.157***	-0.167	-0.178***	-0.152***	-0.107***
	(0.044)	(0.079)	(0.042)	(0.146)	(0.049)	(0.036)	(0.0141)
$\Delta \log(LP)$	-0.707	0.221	1.319**	-0.424	1.458**	0.261	-0.401***
	(0.442)	(0.345)	(0.635)	(0.430)	(0.692)	(0.314)	(0.0623)
$\Delta \log(LP) * \log(LP)$	0.522	-3.082***	2.874*	-4.559**	2.382*	1.172	-0.318***
	(0.872)	(1.116)	(1.602)	(2.010)	(1.364)	(1.037)	(0.123)
R^2	0.986	0.870	0.922	0.982	0.952	0.982	0.325
Observations	420	357	882	462	1407	2184	8116
IV tests, p-values :							
Sargan test	0.08	0.44	0.08	0.97	0.11	0.90	0.18
DWH test	0.00	0.00	0.00	0.00	0.1	0.62	0.00

Column (7) is estimated on the sectoral database, wages are used instead of Labor Productivity.
Instruments: education and capital stock, in level and first difference, for col. (1) to (6); capital stock and intermediate inputs for col. (7)

- Income channel dominates in the long run
- Income channel or substitution channel dominates on the short run, depending on the sub-period

5. Estimate results

➢ **Table 3 – Impact of hours worked on productivity, IV estimates**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Sample	Country level						Industry level[(a)]
Dep. var.	log(*LP*)						log(*w*)
Period	1891-1913	1919-1938	1950-1994	1995-2019	1950-2019	1891-2019	1995-2019
$\log(H)$	-0.625*	-0.366**	-0.654***	-0.384***	-0.640***	-0.624***	-0.690***
	(0.276)	(0.152)	(0.084)	(0.126)	(0.080)	(0.074)	(0.180)
$\log(KI)$	0.212***	0.299***	0.635***	0.233***	0.613***	0.564***	0.110***
	(0.033)	(0.055)	(0.013)	(0.028)	(0.013)	(0.013)	(0.00547)
R^2	0.993	0.976	0.985	0.995	0.991	0.997	0.718
Observations	462	399	924	504	1449	2310	8116
IV tests, p-values							
Sargan test	0.86	0.43	0.22	0.68	0.83	0.85	0.13
DWH test	0.12	0.00	0.47	1.00	0 .02	0.02	0.00

Column (7) is estimated on the sectoral database, wages are used instead of Labor Productivity. Instruments: hours worked in the two closest countries for col. (1) to (6) and of the two closest industries in the same country for col. (7).

- Decreasing returns of hours worked in the long run, consistent with Bourlès & Cette (2007), Aghion *et al.* (2009), Cette, Chang & Konte (2011) and Bourlès, Cette & Cozarenco (2012)

6. Conclusion

- **The three main results**:
  - **The income channel dominates the substitution channel in the long term**
    An increase in productivity or wage reduces the labor supply through a decrease of hours, the long-term elasticity being about -0.1 to -0.2 depending on the sub-period and the dataset
  - **In the short term, there is no clear hierarchy between the income and the substitution channels**: depends on sub-periods and sets of countries
    It suggests that the short-term impact of productivity or wage changes on hours depends on other variables that differ among countries and sub-periods
  - **The fatigue channel dominates the fixed-cost channel**
    A decrease of hours increases the productivity or wage per hour, the elasticity being about -0.4 to -0.6 depending on the sub-period and the dataset

6. Conclusion

- **Using estimation results** (Table 2, column 4), assuming the very simple hypothesis that digital revolution could have the same impact on productivity than the previous revolution observed in the US from 1900 to 1975
  - **Hours could decrease, by about 0.45% per year**
  - Starting at about 1840 hours in the current period, **at the end of the century** hours worked per worker could in average be about **1335 hours per year**
  - It corresponds to about **25 hours per week** on average
  - **Still above the 15 hours expected by Keynes (1930) for 2030**