

**Looking for
productivity gains in the 90s:**

**Econometric Evidence on French firm
level data**

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ISSUES

**In the 90s, in France and in many Developed Countries,
Massive investment in IT,
Acceleration of MFP (Multifactor Productivity)**

Is there a link?

Empirical evidence with the **firm level survey** *Changements Organisationnels et Informatisation:*

IT Adoption Between 1994 and 1997,

New Work Practices used in 1997

And the 2 **Tax Sources** *Bénéfices Réels Normaux* and *Déclarations Annuelles des Données Sociales:*

MFP growth at the firm level

Between 1994 and 1997 and 1994 and 1998

Issues:

- ⇒ Do IT adoption increase MFP growth?
- ⇒ Does the effect of IT on MFP growth depend on the Use of New Work Practices?
- ⇒ Do IT affect the Inputs Efficiencies in the same way?
- ⇒ In particular, is the effect homogeneous within the workforce (skill, age and gender)?

MAIN RESULTS

- **Internet Adoption is correlated with MFP growth**
- **Internet Adoption and MFP growth correlation do not depend on Work Practices**
- **Internet Adoption do not increase Inputs Efficiencies in the same Way: it increases more Skilled and Female Efficiencies**

- **Other IT Adoption do not increase MFP Growth**
 - Personal Computers Connected to A Network,
 - Personal Computers Not Connected to A Network,
 - Mainframe Computers,
 - Transfer of Data Within the Firm,
 - Transfer of Data With Clients or Suppliers
- **Taking into account New Work Practices ...**
- **... or a Different Effect on each Inputs Efficiencies do not change the results**

FRAMEWORK

First Set of Regressions:

$$\Delta \ln MFP = \alpha + \beta \times IT$$

with $\Delta \ln MFP =$ Multifactor Productivity or S.R.

and $IT =$ IT Adoption

Valid with A Technology of the Type:

$$Y = F(A \times X_1, \dots, A \times X_n)$$

$A =$ TFP not observed, measured with MFP

$$\Delta \ln A = a + b \times IT$$

Issue: Returns to IT can be larger than their costs

Excess Returns => Impact on TFP growth

Second Set of Regressions:

$$\Delta \ln MFP = \alpha + \beta \times IT + \gamma \times IT \times NWP$$

with $NWP =$ Use of New Work Practices

Issue: Do firms need to use New Work Practices to get all the benefits from IT?

Third Set of Regressions:

$$\Delta \ln MFP = \alpha + \beta \times IT + \sum (\beta_i - \beta) \times \pi_i \times IT$$

with $\pi_i =$ Cost Share of Input i

Valid with A Technology of the Type:

$$Y = F(A_1 \times X_1, \dots, A_n \times X_n)$$

$$\Delta \ln A_i = a + (b_i - b) \times IT$$

A_i = The Efficiency of Input i can be affected differently by IT than that of Input j .

Interacting IT and Inputs Cost Shares identifies the effect of IT on each Input Efficiency

Issue: Is the effect of IT on Inputs homogeneous?

A Usual Assumption in the Literature Measuring the Effect of IT on TFP growth

But not in the Literature Measuring the Skill Bias of IT

MEASURING *MFP*, *IT* AND NEW WORK PRACTICES

The **firm level tax source** *Bénéfices Réels Normaux (BRN)*

⇒ Employment, capital stock, materials and production in 1994, 1997 and 1998

The **employee level tax source** *Déclarations Annuelles des Données Sociales (DADS)*, aggregated at the firm level:

⇒ Number of hours and cost of **24 categories of employees** (skill x age x gender) in 1994, 1997 and 1998

$$\Delta \ln MFP = \Delta \ln Y - \sum \pi_i \times \Delta \ln X_i$$

X_i = materials, capital, set of 24 labor inputs

The **firm-level Survey** *Changements organisationnels et Informatisation (COI)*:

⇒ 4283 firms, Manufacturing, More than 20 employees

⇒ IT Adoption Between 1994 and 1997: 6 measures

⇒ New Work Practices in 1997: 17 measures

Merging *BRN*, *DADS* ⇒ 20764 firms

Merging the resulting file with *COI* ⇒ 3423 firms

Elementary Cleaning on *MFP* ⇒ **3405 firms**

Some features of firms adopting IT

Table 1: Statistics on MFP growth and IT adoption Between 1994 and 1997

| | Full Sample | Firms of more than 100 employees in 1994 | Firms belonging to a group | Firms in IT producing industries | Firms exporting more than 50% of their sales | |
|----------------------------------|---|--|----------------------------|----------------------------------|--|------|
| MFP Growth between 1994 and 1997 | 0.020 | 0.018 | 0.023 | 0.104 | 0.022 | |
| IT adoption | Internet | 0.41 | 0.60 | 0.54 | 0.65 | 0.55 |
| | Personal computers connected to a network | 0.41 | 0.48 | 0.45 | 0.45 | 0.42 |
| | Personal computers not connected to a network | 0.17 | 0.16 | 0.17 | 0.13 | 0.17 |
| | Mainframe computers | 0.11 | 0.12 | 0.13 | 0.09 | 0.12 |
| | Transfer of data within the firm with a computer system | 0.36 | 0.45 | 0.43 | 0.46 | 0.35 |
| | Transfer of data with clients/ suppliers with a computer system | 0.29 | 0.41 | 0.37 | 0.36 | 0.31 |
| Number of firms | 3405 | 1594 | 1972 | 368 | 460 | |

New Work Practices of firms Adopting IT

Table 2: Statistics on New Work Practices in 1997 according to IT adoption Between 1994 and 1997

| | IT adoption between 1994 and 1997 | | |
|---|-----------------------------------|----------|---|
| | Full Sample | Internet | Personal computers connected to a network |
| Number of Tasks Outsourced (from 0 to 3) | 1.34 | 1.51 | 1.41 |
| Use of ISO 9001, ISO 9002 or EAQF Certification | 0.48 | 0.63 | 0.55 |
| Use of Other Certification or Total Quality Management | 0.34 | 0.43 | 0.39 |
| Use of Value Analysis, Functional Analysis or AMDEC method | 0.27 | 0.39 | 0.33 |
| Use of 5S Method or Total Productive Maintenance | 0.17 | 0.25 | 0.21 |
| Organization in Profit Centers | 0.30 | 0.45 | 0.35 |
| Use of Formal in-house Customer / Supplier Contracts | 0.28 | 0.37 | 0.32 |
| System of Just-In-Time Delivery | 0.36 | 0.45 | 0.43 |
| System of Just-In-Time Production | 0.36 | 0.43 | 0.42 |
| More than 10% of the workers in Self Managed Team (either production workers or other workers) | 0.38 | 0.44 | 0.42 |
| More than 10% of the workers in Problem Solving Groups (either production workers or other workers) | 0.40 | 0.50 | 0.44 |
| More than 10% of the workers in Project Teams (either production workers or other workers) | 0.36 | 0.48 | 0.41 |
| Number of Tasks Production Workers are Responsible for (from 0 to 3) | 1.41 | 1.65 | 1.52 |
| Suppliers or Subcontractors take part in designing end-products | 0.41 | 0.50 | 0.45 |
| Suppliers or Subcontractors make Just-In-Time Deliveries | 0.51 | 0.57 | 0.54 |
| Suppliers or Subcontractors comply with ISO standards or other formal Quality Approaches | 0.63 | 0.77 | 0.68 |
| Use of Subcontracting to adjust output to demand | 0.57 | 0.64 | 0.60 |
| Number of firms | 3405 | 1384 | 1390 |

New Work practices in 1997

Inputs Shares of firms Adopting IT

Table 3: Statistics on average inputs shares according to IT adoption

| | IT adoption between 1994 a | | |
|-----------------------------|----------------------------|----------|---|
| | Full Sample | Internet | Personal computers connected to a network |
| Capital | 0.10 | 0.11 | 0.10 |
| Materials | 0.58 | 0.60 | 0.59 |
| Labor | 0.32 | 0.29 | 0.30 |
| Male | 0.23 | 0.22 | 0.23 |
| Female | 0.08 | 0.07 | 0.08 |
| Employees below 25 | 0.01 | 0.01 | 0.01 |
| Employees between 25 and 35 | 0.08 | 0.08 | 0.08 |
| Employees between 35 and 50 | 0.15 | 0.14 | 0.15 |
| Employees above 50 | 0.07 | 0.06 | 0.06 |
| Unskilled | 0.07 | 0.05 | 0.06 |
| Skilled | 0.13 | 0.11 | 0.12 |
| Highly skilled | 0.13 | 0.14 | 0.13 |
| Number of firms | 3405 | 1384 | 1390 |

Only Internet Adoption is correlated with MFP growth

$$\Delta \ln MFP = \alpha + \beta \times IT$$

Table 4: Regressions of MFP growth on various IT adoption variables

| Internet | Personal computers connected to a network | Personal computers not connected to a network | Mainframe computers | Transfer of data within the firm with a computer system | Transfer of data with clients or suppliers with a computer system |
|----------|---|---|---------------------|---|---|
| 0.011* | 0.006 | 0.003 | 0.002 | -0.001 | 0.002 |
| (0.005) | (0.004) | (0.005) | (0.006) | (0.004) | (0.005) |

Effect on annual MFP growth with $VA = 1.1\%/3/0.58*0.41 = 0.3\%$

To compare to an acceleration from 0.0% to 0.9% from 90-95 to 95-02

*The correlation of Internet Adoption with
MFP growth do not depend on New Work
Practices*

$$\Delta \ln MFP = \alpha + \beta \times IT + \gamma \times IT \times NWP$$

But Internet Adoption does not affect Inputs

Efficiencies homogeneously

$$\Delta \ln MFP = \alpha + \beta \times IT + \sum (\beta_i - \beta) \times \pi_i \times IT$$

Table 6: Regressions of MFP growth on Internet Adoption, Inputs Shares and Their Interactions

| | With MFP growth between 1994 and 1997 | With MFP growth between 1994 and 1998 |
|--|--|--|
| Internet | 0.174 (0.230) | -0.414 (0.420) |
| Share of capital in total cost x Internet | -0.150 (0.235) | 0.529 (0.443) |
| Share of materials in total cost x Internet | -0.166 (0.230) | 0.408 (0.418) |
| Share of female labor in total cost x Internet | 0.213 * (0.080) | 0.341 * (0.099) |
| Share of employees between 25 and 35 years in total cost x Internet | -0.388 (0.309) | 0.103 (0.525) |
| Share of employees between 35 and 50 years in total cost x Internet | -0.650 * (0.277) | -0.355 (0.470) |
| Share of employees above 50 years in total cost x Internet | -0.244 (0.298) | 0.568 (0.432) |
| Share of skilled in total cost x Internet | 0.263 * (0.118) | 0.428 * (0.156) |
| Share of highly skilled in total cost x Internet | 0.329 * (0.114) | 0.414 * (0.151) |

Relative to the Efficiency of Employees Young, Men and Unskilled, IT adoption increases the Efficiency of:

Women: +21.0%

Skilled and Highly Skilled: +26.0% and +33%

Very large compared to the Effect on MFP growth: 1.1%

But Imprecise Estimates of Effects on Efficiencies

***Other IT adoption not correlated with MFP
growth ... even when taking into account
New Work Practices***

$$\Delta \ln MFP = \alpha + \beta \times IT + \gamma \times IT \times NWP$$

Table 5 : Regressions of MFP growth on the Adoption of Personal Computers Connected in a Network, Various Organizational Practices and The Interaction of Both Variables. Estimates of the Interaction Reported in The Table.

| | |
|---|-------------------|
| Number of Tasks Outsourced (from 0 to 3) | 0.000 0.004 |
| Use of ISO 9001, ISO 9002 or EAQF Certification | -0.023 * 0.008 |
| Use of Other Certification or Total Quality Management | 0.003 0.009 |
| Use of Value Analysis, Functional Analysis or AMDEC method | -0.012 0.009 |
| Use of 5S Method or Total Productive Maintenance | -0.011 0.010 |
| Organization in Profit Centers | -0.011 0.009 |
| Use of Formal in-house Customer / Supplier Contracts | -0.005 0.009 |
| System of Just-In-Time Delivery | -0.015 0.009 |
| System of Just-In-Time Production | -0.015 0.009 |
| More than 10% of the workers in Self Managed Team (either production workers or other workers) | -0.001 0.009 |
| More than 10% of the workers in Problem Solving Groups (either production workers or other workers) | -0.011 0.008 |
| More than 10% of the workers in Project Teams (either production workers or other workers) | -0.023 * 0.008 |
| Number of Tasks Production Workers are Responsible for (from 0 to 3) | -0.007 0.004 |
| Suppliers or Subcontractors take part in designing end-products | -0.003 0.008 |
| Suppliers or Subcontractors make Just-In-Time Deliveries | -0.014 0.009 |
| Suppliers or Subcontractors comply with ISO standards or other formal Quality Approaches | -0.019 * 0.009 |
| Use of Subcontracting to adjust output to demand | -0.003 0.009 |

*The impacts of Other IT adoption on Inputs
Efficiencies are not different from one input
to another*

$$\Delta \ln MFP = \alpha + \beta \times IT + \sum (\beta_i - \beta) \times \pi_i \times IT$$

*=> Do not explain why Other IT adoption are
not correlated with MFP growth*

CONCLUSION

- Internet Adoption is correlated with MFP growth

Could explain a significant part of the acceleration of MFP in the 90s (0.3 point of 0.9%)

Associated with Very large Redistribution of Efficiencies between Inputs

But the correlation do not depend on New Work Practices

- Other IT adoption not correlated with MFP growth
- Selectivity issue not treated here
- Does not completely address the issue of Skilled-Biased Technical Change since:

$$d \ln(X_1/X_2) = (\sigma - 1)d \ln(A_1/A_2) + \sigma d \ln(p_2/p_1)$$

$d \ln(A_1/A_2) > 0 \Rightarrow$ upward shift in the relative demand for Input 1 iff $\sigma > 1$

Impact of control variables on the estimate of the impact of Internet on MFP growth

Table A: Regressions of MFP growth on Internet Adoption and various control variables

| | Without control variables | Without IT producing industry dummies | With IT producing industry dummies | With the past Solow residual change |
|---|---------------------------------|--|---|--|
| Internet | 0.018* (0.004) | 0.020* (0.005) | 0.011* (0.005) | 0.012* (0.005) |
| Constant | 0.002 (0.003) | 0.004 (0.007) | 0.007 (0.007) | 0.009 (0.007) |
| Car industry | - | 0.020 (0.011) | 0.021* (0.011) | 0.016 (0.011) |
| Equipment industry | - | 0.026* (0.007) | 0.005 (0.007) | 0.006 (0.007) |
| Intermediate goods industry | - | -0.012* (0.006) | -0.021* (0.006) | -0.021* (0.005) |
| Energy industry | - | 0.016 (0.018) | 0.019 (0.018) | 0.019 (0.018) |
| Electric and electronic equipment industry | - | - | 0.087* (0.011) | 0.084* (0.011) |
| Electric and electronic component industry | - | - | 0.091* (0.011) | 0.093* (0.011) |
| Between 40 and 90 employees | - | -0.005 (0.007) | -0.003 (0.007) | -0.005 (0.006) |
| Between 90 and 300 employees | - | -0.011 (0.007) | -0.010 (0.007) | -0.011 (0.007) |
| Above 300 employees | - | -0.021* (0.008) | -0.022* (0.008) | -0.023* (0.007) |
| Group dummy | - | 0.015* (0.006) | 0.015* (0.006) | 0.017* (0.005) |
| Share of exports in sales | - | -0.009 (0.011) | -0.006 (0.010) | 0.000 (0.011) |
| Herfindahl Index | - | -0.040 (0.022) | -0.051* (0.022) | -0.056* (0.022) |
| Change in the Solow residual between 93 and 94 | - | - | - | -0.159* (0.075) |

***Treating the simultaneity bias with the system
estimation proposed by Griliches and
Mairesse (1984)***

Table B: Elasticities of production growth to inputs and Internet Adoption

| | Direct Estimation of the production function | Semi-reduced form with labor and capital as quasi-fixed inputs | Semi-reduced form with capital as quasi-fixed input |
|-------------|---|---|--|
| Materials | 0.712* (0.012) | 0.574 - | 0.574 - |
| Labor input | 0.195* (0.014) | 0.169* (0.011) | 0.320 - |
| Capital | 0.059* (0.010) | 0.112* (0.008) | 0.039* (0.001) |
| Internet | 0.004 (0.005) | 0.013* (0.004) | 0.004* (0.001) |