Information Technology and Returns to Scale

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Online Appendix.

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OA.1 Proofs and Derivations for the Result in the Main Paper

OA.1.1 Proofs for Lemmas and Propositions in the Main Paper

Proof for Proposition 1. From the definition of the elasticity of substitution (6) in the case of aggregate IT intensity, we find:

$$1-\overline{\sigma}_j = \frac{1}{\overline{\Omega}_{-j}\overline{\Omega}_j}\frac{\partial}{\partial \log W_j}\left(\int \Lambda_i^c \Omega_{j,i} di\right),$$
$$= \frac{1}{\overline{\Omega}_{-j}\overline{\Omega}_j}\int \Lambda_i^c \Omega_{j,i}\left(\frac{\partial \log \Omega_{j,i}}{\partial \log W_j}+\frac{\partial \log \Omega_{j,i}}{\partial \log Y_i}\frac{\partial \log Y_i}{\partial \log W_j}+\frac{\partial \log \Lambda_i^c}{\partial \log W_j}\right)di,$$

where we have let $\Omega_{-j,I} \equiv 1-\Omega_{j,i}$ and where the first term inside the parentheses captures the within-firm response and the remaining terms the between firm response. Using Equation (6), within firm response is simply given by $\int \Lambda_i^c \frac{\Omega_{j,i}\Omega_{-j,i}}{\overline{\Omega}_j\overline{\Omega}_{-j}}\left(1-\sigma_{j,i}\right) = \left(1-\nu_j\right)\left(1-\mathbb{E}^v\left[\sigma_{j,i}\right]\right)$, we have used the definition of ν_j and the fact that

$$\nu_j \equiv \frac{\mathbb{V}^c\left[\Omega_{j,i}\right]}{\overline{\Omega}_j\,\overline{\Omega}_{-j}} = \frac{\overline{\Omega}_j\,\overline{\Omega}_{-j}-\mathbb{E}^c\left[\Omega_{j,i}\Omega_{-j,i}\right]}{\overline{\Omega}_j\,\overline{\Omega}_{-j}}.$$

Using the fact that $\int \Lambda_i^c \frac{\partial \log \Lambda_i^c}{\partial \log W_j}=0$, we can write the between firm as

$$\text{between} = \int \Lambda_i^c\left(\frac{\Omega_{j,i}}{\overline{\Omega}_{-j}\overline{\Omega}_j}\frac{\partial \log \Omega_{j,i}}{\partial \log Y_i}\frac{\partial \log Y_i}{\partial \log W_j}+\frac{\Omega_{j,i}-\overline{\Omega}_j}{\overline{\Omega}_{-j}\overline{\Omega}_j}\frac{\partial \log \Lambda_i^c}{\partial \log W_j}\right)di,$$
$$= \int \Lambda_i^c\left[\frac{\Omega_{j,i}}{\overline{\Omega}_{-j}\overline{\Omega}_j}\frac{\partial \log \Omega_{j,i}}{\partial \log Y_i}\frac{\partial \log Y_i}{\partial \log W_j}+\frac{\Omega_{j,i}-\overline{\Omega}_j}{\overline{\Omega}_{-j}\overline{\Omega}_j}\left(\left(1-\frac{1}{\lambda}\right)\frac{\partial \log Y_i}{\partial \log W_j}-\frac{\partial \log \mathcal{E}_i}{\partial \log W_j}-\frac{\partial \log \mathcal{E}_i}{\partial \log Y_i}\frac{\partial \log Y_i}{\partial \log W_j}\right)\right]di,$$
$$= -\lambda\int \Lambda_i^c\frac{\Omega_{j,i}\Omega_{-j,i}}{\overline{\Omega}_{-j}\overline{\Omega}_j}\eta_i\frac{\Omega_{j,i}^m-\overline{\Omega}_j^m}{1+\lambda\mathcal{E}_i^m}-\int \Lambda_i^c\frac{\Omega_{j,i}-\overline{\Omega}_j}{\overline{\Omega}_{-j}\overline{\Omega}_j}\left(\left(\lambda-1-\lambda\mathcal{E}_i^s\right)\frac{\Omega_{j,i}^m-\overline{\Omega}_j^m}{1+\lambda\mathcal{E}_i^m}+\frac{\Omega_{j,i}\Omega_{-j,i}}{\mathcal{E}_i}\eta_i\right)di,$$
$$= -\frac{\lambda\,\overline{\mathcal{E}}}{1+\lambda\overline{\mathcal{E}}^m}\frac{\mathbb{E}^p\left[\left(\Omega_{j,i}^m-\Omega_{j,i}\right)\left(\Omega_{j,i}^m-\overline{\Omega}_j^m\right)\right]}{\overline{\Omega}_{-j}\overline{\Omega}_j}-\frac{\mathbb{E}^c\left[\left(\Omega_{j,i}-\overline{\Omega}_j\right)\left(\Omega_{j,i}^m-\Omega_{j,i}\right)\right]}{\overline{\Omega}_{-j}\overline{\Omega}_j}-\frac{\mathbb{E}^c\left[\left(\Omega_{j,i}-\overline{\Omega}_j\right)\frac{\lambda-\left(1+\lambda\mathcal{E}_i^s\right)}{1+\lambda\mathcal{E}_i^m}\left(\Omega_{j,i}^m-\overline{\Omega}_j^m\right)\right]}{\overline{\Omega}_{-j}\overline{\Omega}_j},$$
$$= \frac{\mathbb{V}^c\left[\Omega_{j,i}\right]}{\overline{\Omega}_{-j}\overline{\Omega}_j}-\frac{\lambda\,\overline{\mathcal{E}}}{1+\lambda\overline{\mathcal{E}}^m}\frac{\mathbb{E}^p\left[\left(\Omega_{j,i}^m-\Omega_{j,i}\right)\left(\Omega_{j,i}^m-\overline{\Omega}_j^m\right)\right]}{\overline{\Omega}_{-j}\overline{\Omega}_j}-\frac{\mathbb{E}^c\left[\left(\Omega_{j,i}-\overline{\Omega}_j\right)\Omega_{j,i}^m\right]}{\overline{\Omega}_{-j}\overline{\Omega}_j}$$
$$+\frac{\mathbb{E}^c\left[\left(\Omega_{j,i}-\overline{\Omega}_j\right)\left(1-\frac{\lambda\mathcal{E}_i}{1+\lambda\mathcal{E}_i^m}\right)\left(\Omega_{j,i}^m-\overline{\Omega}_j^m\right)\right]}{\overline{\Omega}_{-j}\overline{\Omega}_j},$$
$$= \frac{\mathbb{V}^c\left[\Omega_{j,i}\right]}{\overline{\Omega}_{-j}\overline{\Omega}_j}-\frac{\lambda\,\overline{\mathcal{E}}}{1+\lambda\overline{\mathcal{E}}^m}\frac{\mathbb{E}^p\left[\left(\Omega_{j,i}^m-\overline{\Omega}_j\right)\left(\Omega_{j,i}^m-\overline{\Omega}_j^m\right)\right]}{\overline{\Omega}_{-j}\overline{\Omega}_j},$$

$$= \nu_j \left(1 - \frac{\lambda \overline{\mathcal{E}}}{1+\lambda \overline{\mathcal{E}}^m} \frac{\mathbb{V}^p\left[\Omega^m_{j,i}\right]}{\mathbb{V}^c\left[\Omega_{j,i}\right]}\right),$$

where in the second equality, we have used Equation (15) and dropped the constant terms $\left(1 - \frac{1}{\lambda}\right) \frac{\partial \log \overline{Y}}{\partial \log W_j}$ and $-\frac{\partial \log \overline{\mathcal{E}}}{\partial \log W_j}$, in the third equality, we have substituted from Equations (6), (7), (8), and (50), in the fourth equality, we have used Equation (9) and definition (17), and in the fifth equality, we have used the equality $\mathcal{E}^m_i = \mathcal{E}_i - 1 + \mathcal{E}^s_i$.

For the aggregate output elasticity of relative IT demand, we have

$$\begin{aligned}
\overline{\eta}_j &= \frac{1}{\overline{\Omega}_{-j}\overline{\Omega}_j} \frac{\partial}{\partial \log Y} \left(\int \Lambda^c_i \Omega_{j,i} di \right), \\
&= \frac{1}{\overline{\Omega}_{-j}\overline{\Omega}_j} \int \Lambda^c_i \Omega_{j,i} \left(\frac{\partial \log \Omega_{j,i}}{\partial \log Y_i} + \frac{\partial \log \Omega_{j,i}}{\partial \log Y_i} \left(\frac{\partial \log Y_i}{\partial \log Y} - 1 \right) + \frac{\partial \log \Lambda^c_i}{\partial \log Y} \right) di,
\end{aligned}$$

where the first term inside the parentheses captures the within-firm response and the remaining terms the between firm response. Using the same logic as the derivations above, within-firm contribution is again given by $(1 - \nu_j)\, \mathbb{E}^v [\eta_i]$. Following similar steps to the case of the aggregate elasticity of substitution, we can compute the between firm component as

$$\begin{aligned}
\text{between} &= \int \Lambda^c_i \left[\frac{\Omega_{j,i}}{\overline{\Omega}_{-j}\overline{\Omega}_j} \frac{\partial \log \Omega_{j,i}}{\partial \log Y_i} \left(\frac{\partial \log Y_i}{\partial \log Y} - 1 \right) + \frac{\Omega_{j,i} - \overline{\Omega}_j}{\overline{\Omega}_{-j}\overline{\Omega}_j} \left(\left(1 - \frac{1}{\lambda} - \frac{\partial \log \mathcal{E}_i}{\partial \log Y_i}\right) \left(\frac{\partial \log Y_i}{\partial \log Y} - 1 \right) - \frac{\partial \log \mathcal{E}_i}{\partial \log Y_i} \right) \right] di, \\
&= -\lambda \int \Lambda^c_i \frac{\Omega_{j,i}\Omega_{-j,i}}{\overline{\Omega}_{-j}\overline{\Omega}_j} \eta_i \frac{\mathcal{E}^m_i - \overline{\mathcal{E}}^m}{1+\lambda \mathcal{E}^m_i} - \int \Lambda^c_i \frac{\Omega_{j,i} - \overline{\Omega}_j}{\overline{\Omega}_{-j}\overline{\Omega}_j} \left[(\lambda - 1 - \lambda \mathcal{E}^s_i) \frac{\mathcal{E}^m_i - \overline{\mathcal{E}}^m}{1+\lambda \mathcal{E}^m_i} + \mathcal{E}^s_i \right] di, \\
&= -\frac{\lambda \overline{\mathcal{E}}}{1+\lambda \overline{\mathcal{E}}^m} \frac{\mathbb{E}^p\left[\left(\Omega^m_{j,i} - \Omega_{j,i}\right) \left(\mathcal{E}^m_i - \overline{\mathcal{E}}^m\right) \right]}{\overline{\Omega}_{-j}\overline{\Omega}_j} + \frac{\mathbb{E}^c\left[\left(\Omega_{j,i} - \overline{\Omega}_j\right) \left(1 - \frac{\lambda \mathcal{E}_i}{1+\lambda \mathcal{E}^m_i}\right) \left(\mathcal{E}^m_i - \overline{\mathcal{E}}^m\right) \right]}{\overline{\Omega}_{-j}\overline{\Omega}_j} - \frac{\mathbb{C}^c\left[\Omega_{j,i}, \mathcal{E}^s_i\right]}{\overline{\Omega}_{-j}\overline{\Omega}_j}, \\
&= -\frac{\lambda \overline{\mathcal{E}}}{1+\lambda \overline{\mathcal{E}}^m} \frac{\mathbb{E}^p\left[\left(\Omega^m_{j,i} - \overline{\Omega}_j\right) \left(\mathcal{E}^m_i - \overline{\mathcal{E}}^m\right) \right]}{\overline{\Omega}_{-j}\overline{\Omega}_j} + \frac{\mathbb{C}^c\left[\Omega_{j,i}, \mathcal{E}^m_i - \mathcal{E}^s_i\right]}{\overline{\Omega}_{-j}\overline{\Omega}_j}, \\
&= \nu_j \left(\frac{\mathbb{C}^c\left[\Omega_{j,i}, \mathcal{E}_i\right]}{\mathbb{V}^c\left[\Omega_{j,i}\right]} - \frac{\lambda \overline{\mathcal{E}}}{1+\lambda \overline{\mathcal{E}}^m} \frac{\mathbb{C}^p\left[\Omega^m_{j,i}, \mathcal{E}^m_i\right]}{\mathbb{V}^c\left[\Omega_{j,i}\right]} \right),
\end{aligned}$$

where in the second equality we have used Equation (50), in the third equality we have used Equation (8) to substitute $\left(\Omega^m_{j,i} - \Omega_{j,i}\right) \mathcal{E}_i$ for $\Omega_{j,i}\Omega_{-j,i}\eta_i$, and in the last equality we have used the fact that $\overline{\Omega}^m_j = \mathbb{E}^p\left[\Omega^m_{j,i}\right]$ and $\overline{\mathcal{E}}^m = \mathbb{E}^p\left[\mathcal{E}^m_i\right]$. □

Proof for Proposition 2. Let W_N denote the price index corresponding to the aggregator $\mathcal{X}_N\left(\boldsymbol{X}_{-I}\right)$ and let $\overline{X}_N \equiv \mathcal{X}_N\left(\overline{\boldsymbol{X}}_{-I}\right)$ denote the aggregate bundle of non-IT inputs. A change in the aggregate supply $\overline{X}_I$ of IT inputs in this setting leads to a change in the relative IT prices $W \equiv W_I / W_N$. We will hence normalize $W_N \equiv 1$.

By definition, the share of non-IT inputs in aggregate income is given by $\overline{FS}_N = \frac{W_N \overline{X}_N}{\overline{P}\,\overline{Y}}$. Since we have normalized the price of the bundle of non-IT inputs to unity and their supplies remain unaffected by the shock, we find:

$$\frac{d\log \overline{Y}}{d\log W_I} = -\frac{d\log \overline{P}}{d\log W_I} - \frac{d\log \overline{FS}_N}{d\log W_I}. \tag{OA.1.1}$$

Using the relation $\overline{FS}_N = \frac{\overline{\Omega}_N}{\mu \overline{\mathcal{E}}}$, we can write:

$$\begin{aligned}
\frac{d\log \overline{FS}_N}{d\log W_I} &= \frac{d\log \overline{\Omega}_N}{d\log W_I} - \frac{d\log \overline{\mathcal{E}}}{d\log W_I}, \\
&= \frac{\partial \log \overline{\Omega}_N}{\partial \log W_I} - \frac{\partial \log \overline{\mathcal{E}}}{\partial \log W_I} + \frac{d\log \overline{Y}}{d\log W_I}\left(\frac{\partial \log \overline{\Omega}_N}{\partial \log \overline{Y}} - \frac{\partial \log \overline{\mathcal{E}}}{\partial \log \overline{Y}}\right), \\
&= \overline{\Omega}_I\left(\overline{\sigma}_I - \frac{\overline{\Omega}_N}{\overline{\mathcal{E}}}\overline{\eta}_I - 1\right) - \frac{d\log Y}{d\log W_I}\left(\overline{\Omega}_I\overline{\eta}_I + \overline{\mathcal{E}}^m - \left(\overline{\mathcal{E}} - 1\right)\right),
\end{aligned} \tag{OA.1.2}$$

where we have used the elasticities of demand:

$$\begin{aligned}
\frac{\partial \overline{\Omega}_N}{\partial \log W_I} &= \overline{\Omega}_N \overline{\Omega}_I \left(\overline{\sigma}_I - 1\right), \\
\frac{\partial \overline{\Omega}_N}{\partial \log \overline{Y}} &= -\overline{\Omega}_N \overline{\Omega}_I \overline{\eta}_I,
\end{aligned}$$

and additionally, from $\int \frac{\overline{\mathcal{E}}}{\mathcal{E}_i}\Lambda_i^r di = 1$ implied by Equation (15), we have also relied on the following result:

$$\begin{aligned}
\frac{\partial \log \overline{\mathcal{E}}}{\partial \log \overline{Y}} &= -\frac{\partial \log \int \Lambda_i^r / \mathcal{E}_i di}{\partial \log Y}, \\
&= -\overline{\mathcal{E}} \int \frac{\Lambda_i^r}{\mathcal{E}_i}\left(\frac{\partial \log \Lambda_i^r}{\partial \log Y} - \frac{\partial \log \mathcal{E}_i}{\partial \log Y_i}\frac{\partial \log Y_i}{\partial \log Y}\right) di, \\
&= -\overline{\mathcal{E}} \int \frac{\Lambda_i^r}{\mathcal{E}_i}\left(\left(1 - \frac{1}{\lambda}\right)\left(\frac{\partial \log Y_i}{\partial \log Y} - 1\right) - \mathcal{E}_i^s \frac{\partial \log Y_i}{\partial \log Y}\right) di, \\
&= \overline{\mathcal{E}} \int \frac{\Lambda_i^r}{\mathcal{E}_i}\left[\mathcal{E}_i^s\left(1 + \lambda\,\overline{\mathcal{E}}^m\right) - (\lambda - 1)\left(\overline{\mathcal{E}}^m - \mathcal{E}_i^m\right)\right]\frac{1}{1 + \lambda\,\mathcal{E}_i^m} di, \\
&= 1 + \overline{\mathcal{E}}^m - \overline{\mathcal{E}}.
\end{aligned}$$

We can also write the GE response of the price index as

$$\frac{d\log\overline{P}}{d\log W_I} = \frac{\partial\log\overline{P}}{\partial\log W_I} + \frac{\partial\log\overline{P}}{d\log\overline{Y}}\frac{d\log\overline{Y}}{d\log W_I},$$
$$= \overline{\Omega}_I\left(1+\tfrac{\overline{\Omega}_N}{\overline{\mathcal{E}}}\overline{\eta}_I\right) + \overline{\mathcal{E}}^m\frac{d\log\overline{Y}}{d\log W_I}.$$

Substituting the above result in Equation (OA.1.1), and using Equation (OA.1.2), we now find

$$\frac{d\log\overline{Y}}{d\log W_I} = -\frac{\overline{\Omega}_I\overline{\sigma}_I}{1+\overline{\mathcal{E}}^m-\left(\overline{\Omega}_I\overline{\eta}_I+\overline{\mathcal{E}}^m-(\overline{\mathcal{E}}-1)\right)},$$
$$= -\frac{\overline{\Omega}_I\overline{\sigma}_I}{\overline{\mathcal{E}}-\overline{\Omega}_I\overline{\eta}_I}.$$

Substituting this expression in Equation (OA.1.2), we find:

$$\frac{d\log\overline{FS}_N}{d\log W_I} = \overline{\Omega}_I\left(\overline{\sigma}_I-\tfrac{\overline{\Omega}_N}{\overline{\mathcal{E}}}\overline{\eta}_I-1\right)+\frac{\overline{\Omega}_I\overline{\sigma}_I}{\overline{\mathcal{E}}-\overline{\Omega}_I\overline{\eta}_I}\left(\overline{\Omega}_I\overline{\eta}_I+\overline{\mathcal{E}}^m-(\overline{\mathcal{E}}-1)\right),$$
$$= \overline{\Omega}_I\left[\overline{\sigma}_I\left(1+\frac{\overline{\Omega}_I\overline{\eta}_I+\overline{\mathcal{E}}^m-(\overline{\mathcal{E}}-1)}{\overline{\mathcal{E}}-\overline{\Omega}_I\overline{\eta}_I}\right)-\tfrac{\overline{\Omega}_N}{\overline{\mathcal{E}}}\overline{\eta}_I-1\right],$$
$$= \overline{\Omega}_I\left[\overline{\sigma}_I\left(\frac{1+\overline{\mathcal{E}}^m}{\overline{\mathcal{E}}-\overline{\Omega}_I\overline{\eta}_I}\right)-\tfrac{\overline{\Omega}_N}{\overline{\mathcal{E}}}\overline{\eta}_I-1\right].$$

□

***Proof for Lemma* 2.** Consider the problem of the firm that starts period t with productivity state variables (θ_{it}, ϕ_{it}) and the stocks of non-IT capital, hardware, and software $(K_{it-1}, H_{it-1}, S_{it-1}, L_{it-1})$. Based on the relaxed Assumption 1′ in Section 4.2.1, we assume that the firm faces potential frictions/adjustment costs in its investments in hardware and non-IT capital, but no adjustment costs for software. Thus, the value function of the firm satisfies :

$$V_t\left(\theta_{it},\phi_{it},\boldsymbol{\tau}_{it},K_{it-1},H_{it-1},S_{it-1}\right) = \max_{Y_{it},L_{it},K_{it},S_{it},H_{it}} \mathcal{P}\left(Y_{it}\right)Y_{it} - W_{L,nt}L_{it} - Q_{S,t}\left(S_{it}-S_{it-1}\left(1-\delta_S\right)\right)$$
$$-\mathcal{C}_t^K\left(K_{it};K_{it-1},\boldsymbol{\tau}_{it}\right)-\mathcal{C}_t^H\left(H_{it};H_{it-1},\boldsymbol{\tau}_{it}\right)$$
$$+\frac{1}{1+r_t}\mathbb{E}_{\theta_{it+1},\phi_{it+1},\boldsymbol{\tau}_{it+1}}\left[V_{t+1}\left(\theta_{it+1},\phi_{it+1},\boldsymbol{\tau}_{it+1},K_{it},H_{it},S_{it}\right)|\mathcal{I}_{it}\right],$$
$$\text{subject to}\qquad Y_{it} = nhCES\left(e^{\theta_{it}}K_{it}^{\alpha}L_{it}^{1-\alpha}, e^{\phi_{it}+\theta_{it}}S_{it}^{\beta}H_{it}^{1-\beta}\right), \tag{OA.1.3}$$

where $\mathcal{P}(Y_{it})$ denotes the downward sloping demand function, $Q_{S,t}$ the unit price of software investments, δ_S the depreciation rate of software stock, $\boldsymbol{\tau}_{it}$ a vector of state variables that account for firm-level hardware and non-IT capital investment distortions, $\mathcal{C}_t^H$ and $\mathcal{C}_t^K$ are generic functions that capture potential adjustment costs for hardware H_{it}, and non-IT capital K_{it}, respectively, and $\mathcal{I}_{it}$ stands for the information set of the firm at time t. Note that the investment in software is given by $S_{it} - S_{it-1}(1-\delta_S)$, and that the constraint defines the production function using Equations (30) and (29).

Let Λ_{it} denote the the Lagrange multiplier corresponding to the constraint on Y_{it} , and derive the first-order condition that determines the firm's choice of software stock S_{it}:

$$Q_{S,t} = \Lambda_{it}\frac{\partial Y_{it}}{\partial X_{I,it}}\frac{\partial X_{I,it}}{\partial S_{it}} + \frac{1}{1+r_t}\mathbb{E}_{\theta_{it+1},\phi_{it+1},\boldsymbol{\tau}_{it+1}}\left[\frac{\partial}{\partial S_{it}}V_{t+1}\left(\theta_{it+1},\phi_{it+1},\boldsymbol{\tau}_{it+1},K_{it},H_{it},S_{it}\right)|\mathcal{I}_{it}\right]. \tag{OA.1.4}$$

From the definition of the value function above, we can compute the second expression on the right hand side using the envelope theorem:

$$\frac{\partial}{\partial S_{it}}V_{t+1}\left(\theta_{it+1},\phi_{it+1},\boldsymbol{\tau}_{it+1},K_{it},H_{it},S_{it}\right) = (1-\delta_S)\,Q_{S,t+1}.$$

Substituting the above in Equation (OA.1.4), we find:

$$\Lambda_{it}\frac{\partial Y_{it}}{\partial X_{I,it}}\frac{\partial X_{I,it}}{\partial S_{it}} = Q_{S,t}\left(1 - \frac{1-\delta_S}{1+r_t}\mathbb{E}_t\left[\frac{Q_{S,t+1}}{Q_{S,t}}\right]\right) \equiv W_{S,t}, \tag{OA.1.5}$$

where the second equality defines the *user cost of software* (the effective price of the stock of software) as $W_{S,t} \equiv Q_t\left(1 - R_{S,t}^{-1}\right)$ where $R_{S,t}$ is the required one-year rate of return for software investments at time t. Equation (OA.1.5) shows that the firm's choice of software satisfies a static first order condition with a corresponding price given by $W_{S,t}$.

We additionally consider the first order condition for labor and simplify the expressions to find

$$W_{L,nt} = \Lambda_{it}\frac{\partial Y_{it}}{\partial X_{N,it}}\frac{\partial X_{N,it}}{\partial L_{it}} = \Lambda_{it}\frac{Y_{it}}{X_{N,it}}\frac{1}{\mathcal{E}_{it}}\left(\frac{e^{\theta_{it}}X_{N,it}}{Y_{it}^{\gamma}}\right)^{1-\frac{1}{\sigma}}(1-\alpha)\frac{X_{N,it}}{L_{it}}, \tag{OA.1.6}$$

$$W_{S,t} = \Lambda_{it}\frac{\partial Y_{it}}{\partial X_{I,it}}\frac{\partial X_{I,it}}{\partial S_{it}} = \Lambda_{it}\frac{Y_{it}}{X_{I,it}}\frac{1}{\mathcal{E}_{it}}\left(\frac{e^{\theta_{it}+\phi_{it}}X_{I,it}}{Y_{it}^{\gamma+\epsilon}}\right)^{1-\frac{1}{\sigma}}\beta\frac{X_{I,it}}{S_{it}}, \tag{OA.1.7}$$

where $W_{L,t}$ and $W_{S,t}$ are the wage rate and the rental price of software, respectively, and Λ_{it} is the marginal revenue of producing an additional unit of output. Next, we divide the two equations Equations (OA.1.6) and (OA.1.7) and rewrite them as

$$\frac{W_{S,t}}{W_{L,nt}} = \frac{\beta}{1-\alpha}\frac{L_{it}}{S_{it}}\left(e^{\phi_{it}}\frac{X_{I,it}}{X_{N,it}}Y_{it}^{-\epsilon}\right)^{1-\frac{1}{\sigma}},$$

$$= \frac{\beta}{1-\alpha}\left(\frac{S_{it}}{L_{it}}\right)^{-\frac{1}{\sigma}}\left(e^{\phi_{it}}\frac{(H_{it}/S_{it})^{1-\beta}}{(K_{it}/L_{it})^{\alpha}}Y_{it}^{-\epsilon}\right)^{1-\frac{1}{\sigma}}.$$

We now write this equation in first differences to find:

$$s_{it} - l_{it} = \sigma\left(w_{L,nt} - w_{S,t}\right) + (\sigma - 1)\left[\phi_{it} - \epsilon y_{it} - \alpha\left(k_{it} - l_{it}\right) + (1-\beta)\left(h_{it} - s_{it}\right)\right].$$

□

Proof for Lemma 3. From firm profit maximization, we have $P_i = \frac{\lambda}{\lambda-1}MC_i$ and from CES demand, we have $P_i = P\left(Y/Y_i\right)^{1/\lambda}$. Combining the two and taking derivatives with respect to the price of IT, we find

$$\frac{\partial \log \overline{P}}{\partial \log W_j} - \frac{1}{\lambda}\frac{\partial \log Y_i}{\partial \log W_j} = \Omega_{j,i}^{m} + \mathcal{E}_i^{m}\cdot\frac{\partial \log Y_i}{\partial \log W_j}.$$

Rearranging the terms yields:

$$\frac{\partial \log Y_i}{\partial \log W_j} = -\lambda\left(\Omega_{j,i}^{m} - \frac{\partial \log \overline{P}}{\partial \log W_j}\right)\left(\frac{1}{1+\lambda\cdot\mathcal{E}_i^{m}}\right). \tag{OA.1.8}$$

From the definition of aggregate output Y, we have:

$$0 = \int \Lambda_i^{r}\frac{d\log Y_i}{d\log W_j}di$$

$$= -\lambda\int \Lambda_i^{r}\frac{\Omega_{j,i}^{m}}{1+\lambda\cdot\mathcal{E}_i^{m}}di + \lambda\left(\int \Lambda_i^{r}\frac{\Omega_{j,i}^{m}}{1+\lambda\cdot\mathcal{E}_i^{m}}di\right)\frac{\partial \log \overline{P}}{\partial \log W_j},$$

this gives the following expression for the pass-through of the price of IT into the price index:

$$\frac{\partial \log P}{\partial \log W_j} = \frac{\int \Lambda_i^{r}\frac{\Omega_{j,i}^{m}}{1+\lambda\cdot\mathcal{E}_i^{m}}di}{\int \frac{\Lambda_i^{r}}{1+\lambda\cdot\mathcal{E}_i^{m}}di},$$

which, in combination with Equation (OA.1.8), leads to Equation (50) if we define $\overline{\Omega}^{m} \equiv$

$\left(1+\lambda\,\overline{\mathcal{E}}^{m}\right)\sum_i \frac{\Lambda_i^r \Omega_{j,i}^m}{1+\lambda\cdot\mathcal{E}_i^m}$ and:

$$\overline{\mathcal{E}}^{m} \equiv \frac{1}{\lambda}\left(\int \frac{\Lambda_i^r}{1+\lambda\cdot\mathcal{E}_i^m} di\right)^{-1} - 1.$$

Alternatively, if we take the partial derivative with respect to aggregate output, we find:

$$\frac{\partial \log \overline{P}}{\partial \log \overline{Y}} - \frac{1}{\lambda}\left(\frac{\partial \log Y_i}{\partial \log \overline{Y}} - 1\right) = \mathcal{E}_i^m \cdot \frac{\partial \log Y_i}{\partial \log \overline{Y}},$$

leading to

$$\frac{\partial \log Y_i}{\partial \log \overline{Y}} = \frac{1+\lambda \frac{\partial \log \overline{P}}{\partial \log \overline{Y}}}{1+\lambda \mathcal{E}_i^m}.$$

Once again, from the definition of Y, we find:

$$\begin{aligned} 0 &= \int \Lambda_i^r \frac{d \log Y_i}{d \log \overline{Y}} di \\ &= \int \Lambda_i^r \frac{1}{1+\lambda\cdot\mathcal{E}_i^m} di + \lambda\left(\int \Lambda_i^r \frac{1}{1+\lambda\cdot\mathcal{E}_i^m} di\right) \frac{\partial \log \overline{P}}{\partial \log W_j}, \end{aligned}$$

leading to Equation Equation (50). □

Proof for Corollary 1. Given the assumptions above, the expression for σ_i immediately follows from Equation (19). The expression for $\eta_{I,i}$ follows from Equation (20) if we note

$$\begin{aligned} \eta_{I,i} &= \frac{1}{\Omega_{I,i}(1-\Omega_{I,i})}\left(\mathbb{E}_i^c\left[\left(\Omega_{I,\omega}-\Omega_{I,i}\right)\mathcal{E}_\omega\right] - \frac{\mathcal{E}_i}{\mathcal{E}_i^m}\mathbb{E}_i^p\left[\Omega_{I,\omega}\left(\mathcal{E}_\omega^m - \mathcal{E}_i^m\right)\right]\right), \\ &= \frac{1}{\Omega_{I,i}(1-\Omega_{I,i})}\left(\mathbb{E}_i^c\left[\left(\Omega_{I,\omega}-\Omega_{I,i}\right)\mathcal{E}_\omega\right] - \mathbb{E}_i^c\left[\frac{\mathcal{E}_\omega}{\mathcal{E}_\omega - 1}\left(\Omega_{I,\omega}-\Omega_{I,i}\right)\left(\mathcal{E}_\omega - \left(\mathcal{E}_i^m - 1\right)\right)\right]\right), \\ &= \frac{1}{\Omega_{I,i}(1-\Omega_{I,i})}\mathbb{E}_i^c\left[\left(\Omega_{I,\omega}-\Omega_{I,i}\right)\mathcal{E}_\omega\left(1 - \frac{\mathcal{E}_\omega - \left(\mathcal{E}_i^m - 1\right)}{\mathcal{E}_\omega - 1}\right)\right]. \end{aligned}$$

□

OA.1.2 Derivations for Other Results in the Main Paper

Proof for the results in Footnote 21. Firm i maximizes profit $\Pi_i = P_i Y_i - \mathcal{C}(Y_i) = \overline{PY}^{\frac{1}{\lambda}} Y_i^{1-\frac{1}{\lambda}} - \mathcal{C}(Y_i)$. The first-order condition is given by

$$0 = \left(1-\frac{1}{\lambda}\right)\overline{PY}^{\frac{1}{\lambda}} Y_i^{-\frac{1}{\lambda}} - \mathcal{C}'(Y_i) = \left(1-\frac{1}{\lambda}\right)\overline{PY}^{\frac{1}{\lambda}} Y_i^{-\frac{1}{\lambda}} - \frac{\mathcal{E}_i}{Y_i}\mathcal{C}(Y_i).$$

Using the definition of the marginal cost elasticity $\mathcal{E}_i^m \equiv \frac{\partial \log \mathcal{C}'(Y_i)}{\partial \log Y_i}$, we can write the second-order condition as

$$0 > -\frac{1}{\lambda}\left(1-\frac{1}{\lambda}\right)\overline{PY}^{\frac{1}{\lambda}} Y_i^{-\frac{1}{\lambda}-1} - \mathcal{E}_i^m \frac{\mathcal{C}'(Y_i)}{Y_i},$$
$$= -\left(\frac{1}{\lambda}+\mathcal{E}_i^m\right)\frac{\mathcal{C}'(Y_i)}{Y_i},$$

where in the equality we have used the first-order condition $\mathcal{C}' = \left(1-\frac{1}{\lambda}\right)\overline{PY}^{\frac{1}{\lambda}} Y_i^{-\frac{1}{\lambda}}$. □

Proof for Equations (14) and (15). Using definitions (6) and (12) and applying the envelope theorem, we have

$$\overline{\Omega}_j\left(\overline{Y};\boldsymbol{W}\right) = \frac{1}{\overline{\mathcal{C}}\left(\overline{Y};\boldsymbol{W}\right)}\int \frac{\partial \mathcal{C}_i\left(Y_i;\boldsymbol{W}\right)}{\partial \log W_j} di = \int \frac{\mathcal{C}_i\left(Y_i;\boldsymbol{W}\right)}{\overline{\mathcal{C}}\left(\overline{Y};\boldsymbol{W}\right)}\frac{\partial \log \mathcal{C}_i\left(Y_i;\boldsymbol{W}\right)}{\partial \log W_j} di,$$

which yields the first part of Equation (14) using definitions (3) and $\Lambda_i^c \equiv C_i/\overline{C}$.

Now, note that using Equations (5) at the micro and macro level, and applying the definition in Equation (13), we have

$$\Lambda_i^c = \frac{C_i}{\overline{C}} = \frac{P_i Y_i/\mu\,\mathcal{E}_i}{\overline{P}\,\overline{Y}/\mu\,\overline{\mathcal{E}}} = \frac{\overline{\mathcal{E}}}{\mathcal{E}_i}\frac{P_i Y_i}{\overline{PY}} = \frac{\overline{\mathcal{E}}}{\mathcal{E}_i}\Lambda_i^r,$$

from which, Equation (13) follows. Using the fact that $\int \Lambda_i^r di = 1$ and the above equalities, the second part of Equation (14) follows. □

Proof for Equations (32) and (33). Dropping the subscripts, the cost minimization problem is given by

$$\min_{X_N, X_I} X_N + X_I W + \chi\left(1-\left(\frac{e^{\theta} X_N}{Y^{\gamma}}\right)^{1-\frac{1}{\sigma}} - \left(\frac{e^{\theta+\phi} X_I}{Y^{\gamma+\epsilon}}\right)^{1-\frac{1}{\sigma}}\right),$$

where χ is the Lagrangian corresponding to the constraint in Equation (31) of the main text. The first order conditions corresponding to X_N and X_I yield

$$X_N = \chi\left(1-\frac{1}{\sigma}\right)\left(\frac{e^{\theta} X_N}{Y^{\gamma}}\right)^{1-\frac{1}{\sigma}},$$
$$W X_I = \chi\left(1-\frac{1}{\sigma}\right)\left(\frac{e^{\theta+\phi} X_I}{Y^{\gamma+\epsilon}}\right)^{1-\frac{1}{\sigma}}.$$

Note that the cost satisfies $C = X_N + WX_I = \chi(1 - 1/\sigma)$ and therefore we can write

$$X_N = C^{\sigma}\left(e^{-\theta}Y^{\gamma}\right)^{1-\sigma}, \qquad X_I = \left(\frac{C}{W}\right)^{\sigma}\left(e^{-\theta-\phi}Y^{\gamma+\epsilon}\right)^{1-\sigma}.$$

Using again, the relation $C = X_N + WX_I$, we find Equations (32), and Equations (33) also follows immediately from the above equalities. □

***Proof for Equation* (38).** Define two functions $f_s(\cdot;\cdot)$ and $f_y(\cdot;\cdot)$ according to

$$f_s(\boldsymbol{d}_{it};\varsigma) \equiv l_{it} - \sigma(w_{S,t} - w_{L,nt}) + (1-\sigma)\epsilon\, y_{it} + (1-\sigma)\left[\alpha(k_{it} - l_{it}) - (1-\beta)(h_{it} - s_{it})\right], \tag{OA.1.9}$$

$$f_y(\boldsymbol{d}_{it};\varsigma) \equiv \frac{\sigma}{\gamma(1-\sigma)}\log\left[e^{\frac{\sigma-1}{\sigma}(\alpha k_{it}+(1-\alpha)l_{it})} + e^{\frac{\sigma-1}{\sigma}(\beta s_{it}+(1-\beta)h_{it}-\epsilon y_{it})+\frac{s_{it}-f_s(\boldsymbol{d}_{it};\varsigma)}{\sigma}}\right]. \tag{OA.1.10}$$

Function f_s is a log-linear function of the data that allows us to express the value of IT-biased productivity ϕ_{it} for any combination of the observed data and model parameters for a firm i at time t as $\phi_{it} = (s_{it} - f_s(\boldsymbol{d}_{it};\varsigma))/(\sigma-1)$. When we substitute this expression for the IT-biased productivity term ϕ_{it} in Equation (35) in the main text, we find function f_y that yields an expression for log output of the firm as $y_{it} = f_y(\boldsymbol{d}_{it};\varsigma) + \theta_{it}/\gamma$, again for any combination of the observed data and model parameters for a firm i at time t. □

***Proof for Equation** (40).* Since the scaled productivity states $\tilde{\boldsymbol{\vartheta}}_{it}$ are linear transformations of the productivity states $\boldsymbol{\vartheta}_{it}$, they inherit the Markov properties of the latter. However, to simplify the expressions in the remainder of this section, it will often prove more convenient to work with scaled productivity states $\tilde{\boldsymbol{\vartheta}}_{it}$. In particular, consider a given set of parameters $\boldsymbol{\rho}$ for the Markov process in Equation (39) and recall the AR(1) Markov process for the evolution of the productivity states. It is straightforward to see that the evolution of the vector of scaled productivity states satisfies $\tilde{\boldsymbol{\vartheta}}_{it} = \tilde{\boldsymbol{\mu}}_t(\tilde{\boldsymbol{\vartheta}}_{it-1};\boldsymbol{\rho},\varsigma) + \tilde{\boldsymbol{u}}_{it}$, where the conditional expectation of current scaled productivity states are given by

$$\tilde{\boldsymbol{\mu}}_t(\tilde{\boldsymbol{\vartheta}}_{it-1};\boldsymbol{\rho},\varsigma) \equiv \begin{pmatrix} \rho_{\theta\theta} & \frac{1}{\gamma(\sigma-1)}\rho_{\theta\phi} \\ \gamma(\sigma-1)\rho_{\phi\theta} & \rho_{\phi\phi} \end{pmatrix}\tilde{\boldsymbol{\vartheta}}_{it-1} + \begin{pmatrix} \frac{1}{\gamma}(\eta_\theta + \mu_\theta t) \\ (\sigma-1)(\eta_\phi + \mu_\phi t) \end{pmatrix}, \tag{OA.1.11}$$

and $\tilde{\boldsymbol{u}}_{it} \equiv \left(u_{\theta,it}/\gamma,\ (\sigma-1)\,u_{\phi,it}\right)'$ is a corresponding vector of scaled productivity innovations. □

***Proof for Equations* (45).** From Equation (32), we have the following expression for the cost function

$$\log \mathcal{C} = \gamma \log Y - \theta + \tfrac{1}{1-\sigma} \log \left(1 + \left(e^{-\phi} W Y^{\epsilon}\right)^{1-\sigma}\right).$$

From definition (4), we find

$$\mathcal{E} \equiv \frac{\partial \log \mathcal{C}}{\partial \log Y} = \gamma + \epsilon \frac{\left(e^{-\phi} W Y^{\epsilon}\right)^{1-\sigma}}{1 + \left(e^{-\phi} W Y^{\epsilon}\right)^{1-\sigma}} = \gamma + \epsilon \Omega_I,$$

where we have used Equation (33) in the last equality. From definition (11) and the fact that $\mathcal{C}' = \mathcal{E}\mathcal{C}/Y$, we find

$$\begin{aligned}
\mathcal{E}^m \equiv \frac{\partial \log \mathcal{E}}{\partial \log Y} + \frac{\partial \log \mathcal{C}}{\partial \log Y} - 1 &= \frac{\epsilon}{\gamma + \epsilon\, \Omega_I} \frac{\partial \Omega_I}{\partial \log Y} + \gamma + \epsilon \Omega_I - 1, \\
&= \frac{\epsilon}{\gamma + \epsilon\, \Omega_I} \left(1 - \Omega_I\right) \Omega_I \eta_I + \gamma + \epsilon \Omega_I - 1, \\
&= \gamma + \epsilon\, \Omega_I \left(1 + \tfrac{1-\Omega_I}{\mathcal{E}} \eta_I\right) - 1, \\
&= \gamma + \epsilon\, \Omega_I^m - 1,
\end{aligned}$$

where in the first equality, we have substituted $\mathcal{E} = \gamma + \epsilon \Omega_I$, in the second equality, we have used the definition of the output elasticity of relative IT demand from Equation (6) and the fact that it equals η_I for the nhCES specification, and in the last equation, we have used the expression for the pass-through from Equation (9). □

OA.2 Data Appendix

In this section, we provide further details about the sources of data used and describe the procedure we use to merge our different data sources, to clean the resulting dataset of outliers, and to compute the firm level capital stock for each asset-type. We also report summary statistics on the key variables used in our analysis, and discuss how we extend our dataset to use it in the context of our macro calibration. We finally discuss the construction of the instruments used in our reduced-form and structural identification strategies throughout the paper.

OA.2.1 List of All Data Sources Used

BRN: These data (INSEE, 2007c) provide income and balance sheet information of firms with sales above a certain thresholds, and some smaller firms that choose to opt in. Most firms in the agriculture industries report to a different tax regime and are not included in the BRN files. Available information includes employment, sales, value added, wage bill, payroll taxes, and the breakdown of investment from 1984 to 2007.

RSI: These data (INSEE, 2007d) provide income and balance sheet information of firms that do not report to BRN. Available information includes employment, sales, value added, wage bill, and payroll taxes from 1984 to 2007.

BIC and ESANE files: These data (INSEE, 1983, 2016) are predecessors and successors of the BRN and RSI files and provide income and balance sheet information of firms prior to 1984 (BIC) and after 2007 (ESANE). These files were used to harmonize firms' industry identifiers over a long horizon, but can be dispensed with if using an alternative harmonization using only the BRN and RSI files. In the supplementary Online Appendix, we show how results are affected by using only BRN and RSI files for the harmonization.

EAE: These survey-based data (INSEE, 2007a) cover private sector firms. In all sectors, firms with more than 20 employees are exhaustively surveyed with a general questionnaire that provides information about software investment from 1989 to 2007. Outside of manufacturing, firms with less than 20 employees are randomly surveyed with stratified sampling. Among these firms, firms in the transportation and construction sectors with more than 6 employees (or with sales higher than 800 thousand euros) and firms in the trade sector with more than 10 employees are also surveyed with the general questionnaire that contains information on software investments. All other firms with less than 20 employees that are sampled are surveyed with a simplified questionnaire that does not include information about software investment.

DADS: These data (INSEE, 2007b) provide worker-level information for all firms with salaried workers from 1994 to 2007. Available information includes the establishment to which the worker belongs, her wage, hours, and the category of employment at a detailed level.

Customs: These data (DGDI, 2007) provide NC8 product and country of destination level information on exports for all exporting firms. Available information includes the value, weight, and number of units exported by the firm from 1995 to 2007.

BACI Dataset: This dataset (Gaulier and Zignago, 2010) provides information on bilateral trade flows by year and product.

KLEMS: This dataset (The Conference Board, 2023a,b; Stehrer et al., 2019b) provides information on depreciation rates by type of asset.[1]

INSEE National Accounts and Eurostat: These series (INSEE, 2019a; Eurostat, 2019) provide information on aggregate levels of capital and investment by asset type (including hardware and software) and by sectors. In addition, this source provides investment price indices for 38 industries, as well as aggregate value added, employment, in both quantity and nominal value, by industry.

OECD, Banque de France, Corporate Financial Data: These series (OECD, 2020b,a; Banque de France, 2019, 2020; INSEE, 2020) provide information on benchmark interest rates, tax rates, corporate balance sheets, and measures of the cost of capital for firms in France.

Other Data: We also use exchange rate and inflation data to compute the real exchange rate used in the export demand instrument (OECD, 2019; INSEE, 2019b), and correspondence tables for location and industry identifiers (INSEE, 2019d,c). We use data and code from Van Beveren et al. (2012a) to build correspondence tables between product classifications.

OA.2.2 Capital and IT Factor Prices: Sources and Construction

OA.2.2.1 User-Cost of Capital Inputs

We compute the price of capital inputs (software, hardware, and non-IT capital) as the corresponding rental price (user-cost). If the firm invests I_{jt} in capital of type j at time t, the required rate of return R_{jt} of holding on to this investment is given by:

$$R_{jt} = \frac{1 + r_t}{1 - \delta_j} \frac{Q_{jt}}{\mathbb{E}_t \left[Q_{j,t+1} \right]},$$

[1]The dataset is available online at http://www.euklems.net.

where Q_{jt} is the price deflator of investment good of type j for $j \in \{S, H, K\}$ at time t, and r_t is the long-term interest rate on government bonds. The *rental price of capital good of type j* (the effective price), is given by

$$W_{j,t} \equiv Q_{j,t}\left(1 - \frac{1-\delta_j}{1+r_t}\mathbb{E}_t\left[\frac{Q_{j,t+1}}{Q_{j,t}}\right]\right). \quad \text{(OA.2.1)}$$

In practice, we compute the expected investment price inflation $\mathbb{E}_t\left[\frac{Q_{j,t+1}}{Q_{j,t}}\right]$ as the 3-year moving average of $\frac{Q_{j,t+1}}{Q_{j,t}}$. Below, we extensively discuss the sources of data for price deflators Q_{jt} and depreciation rates δ_j for each asset type.

We use the resulting rental prices to compute measures of factor payments for each asset type at the firm and aggregate levels. In the estimation exercise in Section 4 of the main text, we use the following expression for the price of software relative to wage:

$$\frac{W_{S,t}}{W_{L,t}} \equiv \frac{Q_{S,t}}{W_{L,t}}\left(1 - \frac{1-\delta_S}{1+r_t}\mathbb{E}_t\left[\frac{Q_{S,t+1}}{Q_{S,t}}\right]\right),$$

where $W_{L,t}$ is the local wage. In the empirical application of Section 5 of the main text, we aggregate the rental price of non-IT capital and the local wage to compute the price of non-IT inputs, and the rental prices of software and hardware to compute the price of IT according to the formula for price of a Cobb-Douglas bundle, in line with Equations (29) in the main text:

$$W_{N,t} = \left(\frac{W_{K,t}}{\alpha}\right)^{\alpha}\left(\frac{W_{L,t}}{1-\alpha}\right)^{1-\alpha}, \qquad W_{I,t} \equiv \left(\frac{W_{S,t}}{\beta}\right)^{\beta}\left(\frac{W_{H,t}}{1-\beta}\right)^{1-\beta}, \quad \text{(OA.2.2)}$$

where α and β are given by the share of non-IT capital in the total payments to the bundle of non-IT inputs and the share of software in payments to IT, respectively. The relative price of IT is then equal to the ratio of the IT bundle price to non-IT bundle price:

$$W_t = \frac{W_{I,t}}{W_{N,t}}.$$

OA.2.2.2 Depreciation Rates

For software, the depreciation rate takes the value 0.315 for all sectors, as reported in KLEMS. This depreciation rate is close to the one used by Bloom et al. (2012) for the US (0.36) and also to the value 0.30 proposed by Basu et al. (2003). We also use the KLEMS data for other depreciation rates, aggregating each of the 10 elementary assets into four assets types (hardware, machinery and equipment, intangibles excluding software, and other non-IT capital). The depreciation rate of hardware is an average of Computer Hardware (IT) and Telecommunication Equipment (CT) rates; the depreciation rate for machinery and installed capital is the depreciation rate of Other Machinery Equipment and Weapons (OMach); and the depreciation rate for other capital is an average of Other Building and Structures (OCon) and Transport (TraEq) rates.

Table OA.17 describes the depreciation rates we obtain following this procedure for the different sectors. KLEMS depreciation rates are constant over time at the level of 10 asset classes, but the shares we compute for each asset participating to each asset group are based on the sum of aggregate investment observed in every year.

OA.2.2.3 Application of Investment Price Deflators

We deflate firm-level values of investment in IT and non-IT based on the investment price indices provided by INSEE National Accounts (May 2018 release) at the sector level. We also use these deflators, along with the depreciation rates, to compute the user cost price indices relying on the method discussed in Section OA.2.2.1. We aggregate the values of the price indices we observe for each of the subcomponents of the five asset groups, i.e., software, hardware, machinery and equipment, intangible excluding software, and other non-IT capital, weighting the price of each subcomponent by its share in the asset-level investment. In Section OA.2.2.4 below, we specifically focus on the treatment of quality change in the construction of investment price deflators for IT by INSEE.

OA.2.2.4 Quality Adjustments in IT Investment Price Deflators

Due to fast technical advance and product turnover, accounting for quality change in IT products has posed a major challenge for statistical agencies in constructing price indices for information and communication technologies (Groshen et al., 2017).[2] In this section, we first discuss the approach for quality adjustment in computer (hardware) price deflators by INSEE in France and compare them against the corresponding approaches taken by the BEA and the BLS in the US. We then discuss adjustments we make to the official INSEE series for software prices, and end with the additional correction that we use in the empirical exercise in Section 5 of the main text based on the results of Byrne and Corrado (2017b).

[2]For a discussion of the potentially important implications for the measurement of GDP and productivity, see Byrne et al. (see, e.g., 2016); Ahmad et al. (see, e.g., 2017).

Quality Adjustment in the Construction of Computer Price Indices: INSEE vs. BEA In the US, numerous approaches to quality adjustment for different IT products have been introduced over the years, some of which having also been incorporated in the construction of IT-related price indices by the BLS and the BEA (for brief overviews of these approaches, see Groshen et al., 2017; Byrne and Corrado, 2017a; Sichel, 2019). As we discuss below, similar attempts for incorporating and improving quality adjustments have also been made in the French case by INSEE (for overviews, see Triplett, 2004; Aeberhardt and Bidault, 2018; Aeberhardt et al., 2020). Despite these attempts, available measures both in the US and in France are still likely to be marred by remaining mismeasurement issues.

The favored approach for constructing computer price indices in the US has been a hybrid of the *match* method and the *hedonic* method. The match method is applied by evaluating the price change for products with nearly identical characteristics between the initial and the comparison period. Increasingly, an additional step is employed by applying the hedonic method to impute prices for those products for which a match cannot be found in either of the initial or the comparison periods. Hedonic methods involve running regressions of prices on product characteristics, and using the resulting model to infer the changes in prices that are equivalent to changes in the product characteristics (Berndt et al., 1995; Pakes, 2003; Erickson and Pakes, 2011). While the hedonic methods are sometimes criticized based on the inherent variability in their results depending on the sample (size), they have been slowly integrated into the framework for the construction of the price indices at the BLS and the BEA.

The methodology most commonly used by INSEE for the application of quality adjustment in the case of product entry and exit is the so-called "bridged overlap" method (Aeberhardt et al., 2020; Triplett, 2004). While the hedonic methods explicitly model quality adjustments through observable characteristics, the bridged overlap method relies on an implicit market-based adjustment. Whenever a new product replaces an old product, this method assumes that any price gap is attributable to differences in quality, as long as the two products have coexisted in the same market for at least a brief period (typically less than a year) in the past. INSEE uses the price gap as the measure of quality difference and adjusts for it when accounting for the price change implied by the replacement of the original product by the new one.

INSEE uses hedonic methods for quality adjustment specifically for durable consumer products and rent (Aeberhardt and Bidault, 2018). INSEE statisticians also widely experimented with and explored the possibility to extend the application of these methods to personal computers (e.g., Bourot, 1997; Bascher and Lacroix, 1999; Evans, 2002). Ultimately, they decided against incorporating the hedonic method due to the similarity in the resulting estimates with the bridged overlap (see, e.g., Bascher and Lacroix, 1999) and due to concerns with the variability in the resulting estimates.[3]

Figure OA.1a compares the trends in prices of computer hardware between France, the US, the UK, and Germany. We find that the fall in the price of computer hardware in official statistics is smaller in France (40%) than in its main trading partners (70-90%) in our period of interest. The differences in price trends could stem from differences in the composition in the underlying components of compute hardware or market segmentation that creates variations in the price of the same component across countries. However, it may also stem from inadequate quality adjustment in the French statistics. To explore the consequences of such potential mismeasurement for our results, we introduce an alternative measure for the price of IT by, first, replacing the computer price as measured by INSEE with the average computer price in these three countries and, then, combining it with the price of software investment in France (unchanged). The resulting relative IT price is shown in Figure OA.1b, which now falls by 46% over the period based on this alternative series, compared to 28% for the baseline shock in the main draft. Section OA.6.4 below discusses the general equilibrium response to this alternative measure of shock to IT prices.

Regarding the comparisons in quality adjustment across countries, we highlight two important points. First, even under the extreme assumption that all computer hardware is costlessly tradable, a theoretically consistent approach to quality adjustment is still likely to lead to variations in prices across countries. When computers are used as investment goods, the value that adopting firms attribute to changing characteristics, e.g., processing speed or memory, is likely to vary depending on their technologies and organizational environments. Therefore, we should not expect that the same approaches to quality adjustments would lead to equalizing prices for computer hardware across countries. Second, when it comes to software prices, the assumption of perfect tradability becomes more tenuous since a sizable share of investments take the form of development and maintenance by local firms. In this case, the price trends are likely to be different across countries due to variations in the trends in the wages of technical workers.

Quality Adjustment for Software Price Indices Unlike the computer hardware price index, the price index for software investment provided by INSEE is not quality-adjusted before 2002. Therefore, we compute the average annual variation from 2002 to 2014 re-

[3] Triplett (2004) offers a comprehensive comparison of the technical differences in the hedonic methods employed by the statistical agencies across different countries for measuring IT prices, while Ahmad et al. (2017) provide a comparison of the resulting differences in price trends and their implications for productivity measurements.

ported in the INSEE series and assume that the price of software from 1990 to 2002 followed the same annual trend. Figures OA.14 and OA.15 show the resulting rental price of software and, when combined with computer prices according to the formulas detailed above, the resulting relative price of IT inputs, respectively.

Additional Correction for Potential Quality Mismeasurement A series of recent papers have attempted to combine the most detailed available data and estimates based on recent research to construct price indices for ICT investment products for the US (e.g., Byrne et al., 2016; Byrne and Corrado, 2017a,b; Byrne et al., 2018). As summarized by Byrne and Corrado (2017b), their estimates suggest a potential underestimation of the degree of the fall in quality-adjusted ICT investment prices in the official US statistics.

To explore the effect of a similar potential mismeasurement in the case of official French price series, we use the following correction on the INSEE investment price deflator series to compute an alternative, *corrected* measure of relative IT prices:

$$\Delta \log W_t^{corr} = \Delta \log W_{t-1}^{corr} - corr_t,$$

where we set $W_0^{corr} = W_0$ in 1989, and where $corr_t$ equals the gap between fall in corrected estimates provided in Table 3 of Byrne and Corrado (2017b) and the fall in official BEA prices.[4] The corresponding numbers are 4.2% per year from 1989 to 1994, 4.8% per year from 1995 to 2004, and 5.5% after 2005.

OA.2.3 Other Sources for Macro Data

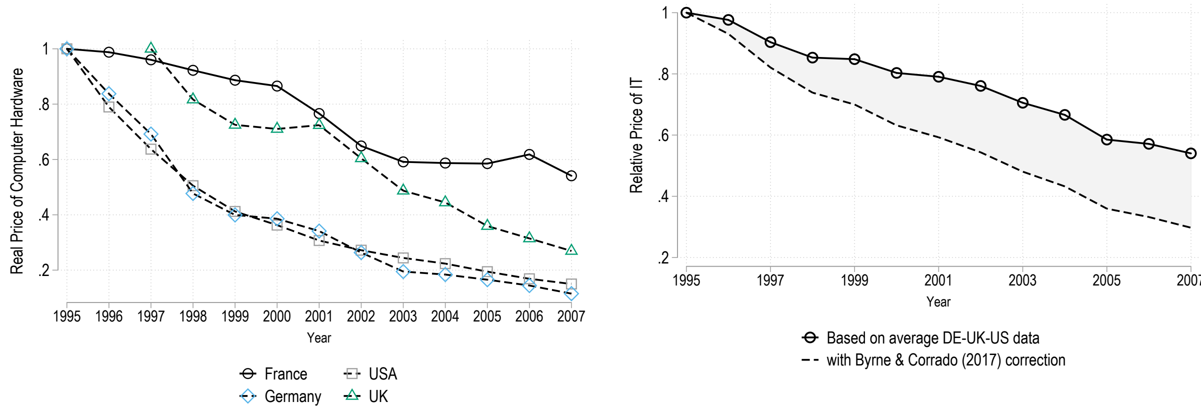
For all other purposes, we use sectoral data on wage bill, value added, employment, and investment and capital by asset type from INSEE National Accounts (May 2018 release). In particular, we use data on aggregate investment and capital in 1989 to initialize firms' capital stocks (see our procedure below in Section OA.2.6). We aggregate asset types into five categories: hardware, software, machinery and equipment, intangibles excluding software, and other (transport and construction) using chained quantity indexes. When aggregating, we average depreciation rates of different asset types using their respective shares in the total nominal value of the resulting capital stock that year. For the computation of rental prices below, we use long-term interest rates on government bonds from the OECD.

[4]See also alternative estimates of the bias in BEA price indices reported in Table 3 of Groshen et al. (2017) based on earlier estimates by Byrne et al. (2016).

Figure OA.1: Alternative Computer Price

(a) Real Computer Price in France and Other Countries

(b) Alternative Fall in Relative IT Prices



Note: Panel (a) presents series of computer prices minus value-added price for the market economy in four countries that used different methods to correct for quality improvements (Sources: EU KLEMS). Panel (b) presents the evolution of an alternative relative price of IT for France, constructed based on the INSEE National Accounts data as in the main text but using the average price of Computers in Germany, the UK and the US; and that constructed by incorporating the same correction based on the estimates of Byrne and Corrado (2017b) for the bias in the official prices of IT investment goods in the US data.

OA.2.4 Sources for Firm-Level Data

Our micro data cover active firms in the corporate sector in France from 1966 to 2016.[5] These firm-level data are collected from surveys and tax records by the French Institute of Statistics (INSEE). The Annual Survey of Firms (EAE) provides information on, among other things, software investment at the firm level. The BRN (normal tax regime) and RSI (simplified tax regime) data provide standard income and employment information for all French firms that have to report to the tax authorities, outside of agriculture. ESANE (after 2007) and BIC (before 1984) files are the predecessors and successors of BRN and RSI files and include similar information. Firms in the BRN files also report their investments in several types of assets, including hardware. Additionally, we rely on the employee-level DADS data and the Customs data for the construction of proxies for the scale and scope of operation of firms. The unique firm identifier SIREN allows us to match these data sources.

[5]Firms are "legal units" with a unique SIREN identification number. We restrict our attention to the following sectors: manufacturing, mining, utility, construction, trade, transportation, accommodation and food services, information and communication, and professional services, excluding agriculture, real estate, finance, public administration, education, and health.

OA.2.4.1 Tax Returns Data

BRN and RSI files (as well as their predecessors BIC and successors ESANE) are our two principal sources of data on firm activity in the universe of French firms. These administrative data are based on tax returns and are available starting in 1984. They cover firms affiliated with the two main French tax regimes: BRN (*Bénéfice Réel Normal*) and RSI (*Régime Simplifié d'Imposition*). The BRN is the standard regime whereas the RSI is a simplified regime intended for small firms. Depending on their domain of activity, firms with revenues above a certain threshold must be affiliated with the BRN regime.[6] These data provide information on the firm's number of employees, sales, value added, total and tangible investment, year of creation, industry, and location. Information on the disaggregated components of firm investment by asset types, including hardware investment, is available in the BRN files starting in 1989. While we rely on the whole sample of RSI and BRN firms for our analysis of macro trends in France (see Section 5 of the main paper and Section OA.6.4 below), we restrict our analysis of capital and investment to firms that appear at least once in the BRN dataset.

The office and computing equipment component of investment in the BRN data provides, to our knowledge, the closest measure for hardware investments of firms in the universe of French firms, despite the fact that it includes non-investment components such as office furniture. We use this variable as our measure of investment in hardware and as our second indicator of IT investment, acknowledging the potential for measurement error due to the presence of non-IT components.

OA.2.4.2 INSEE Survey Data

The EAE (*Enquête Annuelle d'Entreprises*) is a survey-based dataset collected every year from 1982 to 2007. The survey is conducted separately for each broad sector of the French economy (trade, transportation, construction, manufacturing & utility, agrifood, and services), with some variation in the list of questions asked and the sampling methods used. Overall, the data comprehensively covers medium and large firms, i.e., those with more than 20 employees, and surveys a sample of the smaller ones.[7] Starting in the 1990s, large firms are surveyed with a more comprehensive questionnaire that includes questions about software investment of firms.[8]

[6] In 2007, the thresholds were 763,000 euros if the firm operates in trade or real estate sectors, and 230,000 euros otherwise. RSI-only firms have average sales of 102 thousands euros, against 3,848 thousands euros for firms that appear in the BRN files at least once.

[7] The only exception is manufacturing & utility, in which only the large firms are surveyed.

[8] The criterion for inclusion is based on the employment size of the firm at the end of the previous year. This more comprehensive questionnaire has been applied in select sectors starting in 1989, and has been

Firms surveyed by EAE report total investment in software, as the sum of expenditure on 1) software purchased from outside, 2) software created in-house, and 3) investment made in existing software. Our measure of software investment includes all components, and we use the information on the disaggregated components of investment, when available, to ensure that they are compatible with the reported value of total investment in software.[9]

In the EAE files, missing values for software investment are coded as zero. Most of these missing values correspond to the smaller firms, surveyed with the simplified questionnaire which does not include information on investments. We adopt the following strategy to ensure that we distinguish actual zeros from missing data: we consider as missing the software investment of firms that report zero investment and whose employment and sales reported the previous year are below the threshold necessary to be fully surveyed.

OA.2.4.3 Other Sources of Micro Data

We use two additional sources of data. We rely on the employee-level DADS data to find information on the number of plants and the organizational structure of the firm in terms of the occupational mix of employees, including information on IT workers. We also use the Customs data for information on the number of exported products and destination countries, as additional proxies for the scope of operation of firms.

OA.2.4.4 Variable Definition

Sales: Annual sales of the firm from the BRN-RSI files (variable r310).

Material Inputs: Annual material intputs of the firm from the BRN-RSI files, net of inventory variations (sum of r212, r213, r214, r222, minus r315).

Value Added: Annual value added excluding VAT from the BRN-RSI files, following the *Système Unifié des Statistiques d'Entreprises* (SUSE) definition of VAHT.

Employees: Annual employment measured by the total number of employees from the BRN-RSI files (variable e001).

Total investment: Total net investment in tangible and intangible assets from the BRN files (sum of variables i120, i122, i123, minus the sum of variables i130, i132, i133).

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extended to all sectors starting in 1995.

[9]The survey further includes a disaggregation of software investment into these three components, for firms operating in some manufacturing, trade and services industries. Firms operating in the food sector also report the sources of funds (internal or external finance) for the investment.

Tangible investment: Total net investment in tangible assets from the BRN files (variable i120 minus variable i130).

Software investment: Net investment in software assets from EAE files (variable i460). The breakdown of software investment into outside purchase (i461), in-house investment (i462), replacement of existing software and research & development (i463) or using internal (i464) or external (i465) funds available in some industries is used for cleaning purposes.

Intangible investment: Total net investment in intangible assets from the BRN files (sum of variables i122 and i123, minus the sum of variables i132 and i133).

Hardware investment: Net Investment in office equipment from the BRN files (variable i228 minus variable i238).

Machinery and installed investment: Net investment from the BRN files (sum of variables i225 and i226 minus the sum of variables i235 and i236).

Other investment: Net investment in construction, transport, and others from the BRN files (tangible investment minus hardware and machinery and installed investment).

Number of occupational layers: Number of different types of workers within the firm from the DADS files, following the definitions in (Caliendo et al., 2015): CEO, management, supervisor, white collar, blue collar.

Number of IT workers: Annual employment in occupational categories 38 (engineers) and 47 (technicians) in the DADS files.

Number of plants: Number of establishments with salaried workers from the DADS files.

Number of products: Number of NC8 level products exported by the firm according to the Customs data.

Number of destination countries: Number of destination countries that the firm exports to according to the Customs data.

OA.2.4.5 Industry Classifications

The industry classification has changed in BRN and RSI files over the period of interest. The dataset contains industry codes in NAF for years before January 1st, 2003 and in NAF rev. 2 for years after December 31, 2002. There is no one-to one correspondence between the different industry classifications. There however exists for the NAF-NAF rev. 1 a statistical correspondence table that gives the number of firms for which a given link between two industry classifications applies. For this correspondence we keep the most frequent link, which gives us a mapping from NAF to NAF rev. 2, and we keep the most recent NAF rev. 2 code for all firms. We then perfectly match those 5-digits NAF rev. 2 codes to the 38 aggregate industries of the INSEE classification.

OA.2.5 Data Construction and Cleaning

We start with the BRN, RSI, BIC and ESANE files from 1966 to 2016, in which we drop firms that have invalid French unique firm identifiers (SIREN) using the cross-validation algorithm used to generate SIREN numbers. They correspond to firms whose self-reported SIREN identifiers do not match the SIREN identifiers recorded by INSEE. We then collapse observations corresponding to firms that appear in both BRN and RSI regimes in the same year.

OA.2.5.1 Initial Cleaning and Construction of the BRN+RSI Dataset

The BRN and RSI files contain information on the 5-digits industry to which the firm belongs. Since we observe for some firms frequent changes in industry identifiers that are not consistent across datasets, we harmonize industry identifiers by keeping the most recent industry identifier for each firm. Finally we restrict our sample to the 1990-2007 period and exclude firms in the agriculture, finance, real estate and non-market service industries, as well as 439,537 observations (1% of the total number of observations) for which we cannot build industry codes. We restrict our sample to firms that have one or more employees, and that report positive sales, value-added, and wage bill (including taxes on labor). This leaves us with 15,202,793 firm-year observations. We use these data (labelled "BRN+RSI") to compute the decomposition of labor shares and concentration.[10]

In an alternative data construction that is more easily reproducible based on the data available to researchers outside INSEE, we start with the BRN, RSI files from 1989 to 2007. We also harmonize industry identifiers, but on a shorter time period (1989-2007, instead of 1966-2016), therefore these data differ slightly from the benchmark analysis described in the main text and this Online Appendix. In a supplementary Online Appendix, we show that our results are robust to this alternative data construction.

[10]The BIC and ESANE files were included to additionally study the long-run evolution of labor share in France. The results from this part of the project were published in a separate paper (Bauer and Boussard, 2020).

OA.2.5.2 Construction of Local Wage

The BRN and RSI files contain information about the municipality where the headquarters of the firm are located. We match the location of firms within the list of employment areas (*Zone d'emploi*) according to the 1990 definition. We use this information to construct measures of average wages at the level of local employment area. We rely on the employment-weighted average within each employment area of the ratio of total labor costs of firms (including employers contributions to employment). In computing this average, we exclude the top 0.1% and bottom 0.1% of firm-level wages by year and industry.[11]

OA.2.5.3 Construction of the Capital Stocks in the BRN Dataset

Using the SIREN codes, we are able to match the observations from BRN+RSI to observations included in the EAE files, which provide us with information in firm investment in software. We construct measures of the different stocks of capital, including software and hardware, using the procedure described in Section OA.2.6 below, restricting our sample to firms that appear at least once in the BRN files. After the construction of capital stocks, initialized at the start of the year 1990, we discard the first five years of data. We then drop observations with book capital per employee relative to the industry average that is outside of the 99.72% probability range of a fitted distribution (0.28% of observations) and firms with at least one observation in the top 0.1% for investment per employee in any of the five assets listed in Section OA.2.6 (1.85% of observations). There are 6,336,678 firm-year observations from 1995 to 2007 in these data (labelled "BRN"), of which 2,511,960 firm-year observations correspond to firms also surveyed at least once by the EAE (labelled "EAE").[12] We use the BRN sample to establish our facts in Section 2. BRN firms are broadly representative of the aggregate French economy: they account for 76.1% of private value-added and 83.4% of private employment.[13] Table OA.1 reports summary statistics on the three samples, BRN + RSI, BRN, and BRN restricted to EAE firms.

[11] There are 364 employment areas, defined in 1990 as geographical units with more than 25,000 workers within which most of the workforce commutes.

[12] BRN firms that are never surveyed in EAE have average sales of 3,809 thousands euros, against 13,583 thousands euros for surveyed firms.

[13] Tables OA.18–OA.20 present some summary statistics on the representativeness of the BRN dataset for the aggregate private sector of France, excluding agriculture, real estate, and finance.

OA.2.5.4 Matching the BRN Dataset to DADS and Customs Files

To compute our measures of firm scale other than sales and value added, we match with the observations in the DADS with those in the Customs data. DADS data are establishment/employee-level data, which we collapse at the level of the firm, summing employment, wage bill, and hours of employees in each occupational category. Customs data are firm/product/destination-level data, which we collapse at the firm level, summing total exports and counting the number of products and destination countries. We rely on these alternative measure of scale in Section OA.3.1.5. Of the 6,336,678 observations in our BRN sample, 5,895,501 are also in DADS, and 1,711,942 correspond to exporting firms. Some firms in the DADS and Customs data are not present in the BRN files. DADS covers all employers with salaried workers, so it includes non-profits, households as employers, and public employers. Matched DADS observations have on average 36 employees according to the DADS, against less than 10 employees for unmatched firms. Matched customs firms declare total exports of 3.1 million euros on average, against less than 1.7 million euros for unmatched customs firms.

OA.2.5.5 Dataset for the Structural Estimation

In the estimation, we further restrict our sample to EAE firms with positive hardware, and non-IT capital, positive labor and value added, and more than 10 euros of software stock (see Section OA.2.6.2 for a discussion of this choice of threshold) and for which the location of the firm's headquarter is known. These last restrictions bring the number of observations in our estimation sample to 307,504.

OA.2.6 Building Measures of Capital Stock

To compute micro-level capital stock measures, we apply the Perpetual Inventory Method to five asset types: software, hardware, machinery and equipment, intangibles excluding software, and a bundle of other non-IT capital which includes non-dwelling buildings and structures, and transport equipment. For each asset-type j, firm i, and year t, we build capital stocks using the following recursive formula:[14]

$$K_{j,i,t} = K_{j,i,t-1}(1-\delta_j) + \frac{I_{j,t}}{W_{j,t}}, \quad \text{(OA.2.3)}$$

[14]Our procedure closely follows that used by Bloom et al. (2012), who construct capital stock measures based on various surveys of IT expenditure in the UK.

where $W_{j,t}$ stands for the price deflator for asset-type j at time t, and δ_j for the depreciation rate in asset-type j. Below, we discuss how we initialize this recursive formula for each asset-type and for each firm. Total capital stock is the sum of all asset-types stocks, which allows us to fully take into account the heterogeneity of investment composition across firms instead of using a common price and depreciation rate.

OA.2.6.1 Initialization

To accumulate the firm-level stocks of different types of capital given observed values of investment, we need to compute initial values for each type in 1989 ($t = 0$). To do so, we allocate the industry-level capital stocks reported in the macro data in this year across firms depending on their observed shares of industry-level investment.

First, we address the potential mismatch between our micro-level data and the reported macro data. We assume that in each of the 38 industries for which the macro data is available, the ratio of total investment to total stock in our sample is equal to the ratio of investment $\bar{I}^s_{j,0}$ to stock $\bar{K}^s_{j,0}$ reported in the macro data for industry s in asset type j, in the aggregate data:[15]

$$\sum_{i\in s} K_{j,i,0} = \frac{\sum_{i\in s} I_{j,i,0}}{\bar{I}^s_{j,0}} \times \bar{K}^s_{j,0}, \tag{OA.2.4}$$

where $\frac{\sum_{i\in s} I_{j,i,0}}{\bar{I}^s_{j,0}}$ is typically below 1 (0.469 on average, see Table OA.18). This allows us to construct an industry-level stock for our sample of firms.

Next, we assume that the share of each firm in that industry-level stock is given by the share of the firm average investment across all years in that asset-type $I^m_{j,i,0}$ to the sum of the average investments in that asset-type of all firms in that industry. At year 0, the imputed value of the stock of asset j of firm i in industry s is then given by:

$$K_{j,i,0} = \frac{I^m_{j,i,0}}{\sum_{i\in s} I^m_{j,i,0}} \times \frac{\sum_{i\in s} I_{j,i,0}}{\bar{I}^s_{j,0}} \times \bar{K}^s_{j,0}. \tag{OA.2.5}$$

OA.2.6.2 Treatment of Missing Investment Values

There are 279,016 unique firms in the EAE sample, totaling more than 2 million observations. For 25% of those firms, we do not have missing values for software investment since these firms are present in the BRN and EAE data every year from their first entry to their exit.

[15] The aggregate industry levels of stocks and investment are provided by INSEE at the 38 industries level. We use net values of capital at constant replacement cost, which already account for previous years capital depreciation.

Among the remaining firms whose software stocks include some missing values, more than two thirds of the missing values correspond to firms that typically first appear as small firms in the RSI sample, then as larger firms in the BRN sample, and then large enough to be sampled in EAE. Before the first year in which they appear in the EAE data, our PIM procedure leads to low software stocks (all below 10 euros) and those years are dropped from regressions of log software intensity or from the estimation sample. The remaining cases correspond to firms that are not systematically sampled in EAE even after the first year that they are sampled because they remain close to the threshold of size that determines which firms are exhaustively surveyed by EAE.

Similarly, there are 876,091 unique firms in the BRN sample, totaling more than 6 million observations. For 75% of these firms, we do not have any missing values for any investment values for the hardware and other non-IT investment data as these firms are present in the BRN data every year from their first entry to their exit.

When necessary to account for the missing values, we infer them to be zero. Such inferred zeros for the missing values are not used in the regressions corresponding to the IT investment intensity of hardware and software in Figure 1 in the main text and in Table OA.3 below. Moreover, as we restrict our sample to larger firms in Table 5 of the Appendix of main text, the share of firms whose software stocks include some inferred zeros drops considerably: fewer than 1% of firms have more than one missing value in the largest bracket. In our estimation sample, the 307,504 observations corresponds to the 52,169 firms that have positive values, hardware, and other non-IT capital stocks, and stocks of software larger than 10 euros. For these firms, the inferred zeros impact the stocks of the software, hardware, or non-IT capital only if the firm appears in the BRN or EAE data in year $t-1$ and $t+1$ but not in year t. In practice, this impacts fewer than 1% of the firms in the cases of hardware and non-IT capital stocks, and fewer than 10% of the firms in the case of software stock.

OA.2.7 Summary Statistics for the IT Data

Table OA.1 presents the summary statistics of the main variables in our data. The table separately shows the summary statistics for all firms, on the left, and for manufacturing firms, on the right. We have around 15.2 million firm-year observations in the BRN + RSI files from 1990 to 2007, for which we provide standard income statistics. Of those, around 6.3 million observations refer to firms included once in the BRN files from 1995 to 2007, for which we provide statistics on hardware and other non-IT inputs, and around 2.5 million observations refer to firms surveyed at least once by the EAE from 1995 to

Table OA.1: Summary Statistics

	Source	All firms Obs. (Nb)	Mean	Median	Sd	Manufacturing firms Obs. (Nb)	Mean	Median	Sd
Sales	BRN + RSI	15,202,793	2,498.8	265	85,057.3	2,422,365	4,171.0	316.9	60,560.3
Value-Added	BRN + RSI	15,202,793	708.3	106	33,071.6	2,422,365	1,271.8	147.1	25,846.6
Number of Employees	BRN + RSI	15,202,793	13.8	3	480.7	2,422,365	23.3	4	177.0
Wage Bill	BRN + RSI	15,202,793	472.4	74	18,404.6	2,422,365	815.2	109	8,105.5
Labor Share (%)	BRN + RSI	15,202,793	86.2	73.0	813.6	2,422,365	85.2	73.5	1,708.5
Total Investment	BRN	6,336,678	140.2	4.7	9,746.9	1,014,025	269.1	12	4,038.0
Total Capital Stock	BRN	6,336,678	1,205.9	88.6	92,054.5	1,014,025	2,616.0	218.3	30,711.6
Total Cost	BRN	6,336,677	888.2	180.3	33,090.3	1,014,025	1,558.2	303.8	12,468.7
IT Measures									
Software Investment	EAE	2,511,960	5.7	0	520.1	390,632	14.5	0	287.3
Software Stock	EAE	2,511,960	15.4	0	1,197.5	390,632	40.3	0.7	712.8
Hardware Investment	BRN	6,336,678	5.9	0	399.9	1,014,025	9.0	0	170.9
Hardware Stock	BRN	6,336,678	24.0	0	1,832.4	1,014,025	44.8	0	656.8
IT per Worker									
Software Investment	EAE	2,511,960	27.1	0	165.2	390,632	66.2	0	225.8
Software Stock	EAE	2,511,960	80.9	0	3,165.3	390,632	218.3	20.1	7,726.5
Hardware Investment	BRN	6,336,678	171.7	0	786.3	1,014,025	111.0	0	475.5
Hardware Stock	BRN	6,336,678	472.2	0	2,412.0	1,014,025	392.8	0	1,222.7
IT per Unit of Capital									
Software Investment	EAE	2,046,011	21.5	0	1,184.9	362,847	28.8	0	796.0
Software Stock	EAE	2,359,661	3.9	0	28.6	381,562	6.0	0.5	26.8
Hardware Investment	BRN	4,498,705	109.0	0	1,748.3	791,217	68.8	0	1,411.3
Hardware Stock	BRN	5,716,575	38.7	0	127.0	943,285	18.3	0.2	70.5
IT per Unit of Cost									
Software Investment	EAE	2,511,953	0.6	0	4.1	390,632	1.6	0	5.4
Software Stock	EAE	2,511,960	0.6	0	2.9	390,632	1.6	0.2	4.3
Hardware Investment	BRN	6,336,632	3.7	0	28.1	1,014,019	2.5	0	15.6
Hardware Stock	BRN	6,336,677	2.3	0	7.8	1,014,025	1.6	0	4.5

Note: The units for all variables are thousand euros except for those involving intensity, share, or numbers. The units for the IT intensity of labor, capital, and cost are euros per worker, euros per thousand euros of capital, and euros per thousand euros of cost, respectively. Labor share, in percentage points, is defined as the sum of wage bill and payroll taxes divided by value-added. Stock measures are built using the Perpetual Inventory Method (PIM), imputing zero investment for missing data. The table reports hardware and capital inputs for all firms included at least once in the BRN files, and software inputs for all firms surveyed at least once by EAE. Section OA.2.4 describes the data sources for each variable. The period is 1990-2007 for BRN + RSI data, 1995-2007 for BRN and EAE data. For the IT intensity of capital, the number of non missing observations is lower because of the higher occurrence of zeros in the denominator.

2007, for which we provide statistics on software inputs.

As Table OA.1 shows, the distribution of both types of IT investment is highly skewed, much more so than that of the total investment. The modal firm invests zero in both software and hardware, whereas the average firm invests over 5,700 euros in software and 5,900 euros in hardware annually (conditional on being surveyed). The values of investment are higher in manufacturing compared to other sectors. However, manufacturing firms are on average larger than non-manufacturing firms. As we will see below, the differences between sectors is less pronounced when we examine proxies of relative demand for software and hardware.

Table OA.2 reports the intensive and extensive margins of software investment, sepa-

Table OA.2: Software Investment Summary Statistics (1996)

1996	Number of Firms				Average values		Median values
	All	EAE	No software investment	Some software investment	EAE	Some software investment	Some software investment
0-5	214,156	10,970	10,935	35	0.01	2.53	2.13
5-10	135,664	13,970	13,687	283	0.09	4.20	1.83
10-20	58,170	12,003	11,121	882	0.50	6.76	2.74
20-50	48,896	33,614	27,140	6,474	1.61	8.35	3.35
50-100	11,392	9,746	6,662	3,084	4.61	14.58	6.02
100-250	7,200	6,361	3,741	2,620	11.87	28.82	10.98
250-500	2,173	2,006	1,000	1,006	31.22	62.25	31.79
500-1000	938	897	373	524	92.35	158.08	70.81
1000-2500	450	432	164	268	237.73	383.21	160.38
2500-5000	119	112	42	70	517.22	827.55	401.09
+5000	55	51	18	33	5741.85	8873.76	759.20

Note: The first column denote the class size in terms of BRN employment. Columns (2)-(5) count the number of firms for each of the four samples, in each class size : all firms in 1996, firms sampled in EAE in 1996, of which firms that declared zero or missing software investment, and firms that declared positive software investment. Columns (6)-(7) display average software investment for all firms in EAE in 1996 and those that declared positive investment. Column (8) displays median software investment for firms that declared positive software investment.

rately for different classes of firm employment (in year 1996).[16] The likelihood of reporting nonzero investment values is larger among larger firms. Conditional on reporting non-zero investment in software, both the median and mean of the values reported are also greater among larger firms. This relationship appears in all years in our data, e.g., we can observe it in 2006 (cf. Table OA.21). Examining the data on hardware investment also shows a similar pattern (cf. Tables OA.22 and OA.23).

As with the investment measures, our constructed measures of capital in Table OA.1 show evidence of skewness. The median firm has zero stocks of software and hardware capital, while the mean values of software and hardware capital stock are around 15,400 euros and 24,000 euros, respectively.[17]

OA.2.8 Extended IT Data: Mapping Micro Data to Macro Outcomes

In Section 5 of the main text, we apply our theoretical and estimation results to derive predictions for the response of the French macroeconomy to the fall in IT prices. We build the aggregate elasticities from their individual components at the firm-level by augmenting the data we use in the previous sections.

[16] The drop in the coverage of the data (as reflected in the number of observations) for firms with less than 20 employees is due to the design of the EAE survey.

[17] See Tables OA.24, OA.25, OA.26, and OA.27 for the values of IT capital stocks disaggregated by size class.

To use our micro data for studying the macro patterns, we need to overcome two limitations of our data. First, while the BRN+RSI files have near universal coverage of firms in France, we do not observe investments in non-IT capital and hardware for firms that are only present in the RSI file. We also do not observe software investments of firm that are never surveyed by EAE. To include RSI and non-EAE firms in our analysis of macroeconomic trends in France, we impute the factor payments of these firms based on industry-specific relationships between factor payments and size. More specifically, we run the following regression:

$$\log\left(WX_{ijt}\right) = \delta^{y}_{j,s} \cdot y_{it} + \delta^{l}_{j,s} \cdot l_{it} + FE_{s,t} + \xi_{ijt},$$

in the sample of firms with nonzero payments to each factor j (hardware, softwrae, non-IT capital), where WX_{ijt} stands for the payments to production factor j by firm i in industry s in year t, where y_{it} is the logarithm of value added, and where l_{it} is the logarithm of employment. We use this relationship to predict payments to each production factor j for all firms with missing payments. We use the same strategy to impute labor payments for firms in RSI with fewer than 10 employees, since the labor payment data for these firms typically does not include the payments to the owner/entrepreneur, which could constitute a sizable share of labor payments for such small firms.

Second, the definition of IT investments in the INSEE National Accounts are a bit different from the corresponding definitions in our micro-level data. For instance, investment in databases are not included in the stock of productive capital. As another example, our hardware data additionally includes the investments of firms in office furniture as well. We correct all firms' factor payments proportionally to match industry-level factor payments-to-value-added ratios. For each firm i in industry s in year t and for each factor j, we adjust the observed factor payment WX_{ijt} in the data by a multiplicative adjustment factor $A_{j,s,t}$, defined according to

$$A_{j,s,t} \equiv \frac{WX_{s,t} / PY_{s,t}}{\sum_{i\in s} WX_{ijt} / \sum_{i\in s} PY_{it}},$$

where $WX_{s,t}$ and $PY_{s,t}$ stand for the factor payments and value added of the industry at time t based on the INSEE national accounts, and where $\sum_{i\in s} WX_{i,j,t}$ and $\sum_{i\in s} PY_{i,t}$ stand for the sum total of factor payments and value added for that industry at that point in time based on unadjusted firm-level data. This procedure ensures that the relative factor payments in our micro data are compatible with those in the macro data, while preserving the coverage of value added in our micro data.

OA.2.9 Instruments

OA.2.9.1 Export Demand Shock Instruments

As we discuss in Section OA.3.3 below, in our examination of the relationship between firm size and relative IT demand within firm, we rely on demand shocks to different export destinations of firms as an exogenous source of variation in their expected potential for growth. We limit our attention to the sample of exporting firms, and we construct the product-destination-level export demand shocks for firm i at time t as

$$ds_{it}^{P} = \sum_{np} \Lambda_{inp,0} \left(imp_{np,t}^{-FR} - \overline{imp_{p,t}^{-FR}} \right), \tag{OA.2.6}$$

where $\Lambda_{inp,0}$ denotes the initial destination-n/product-p share of firm-i exports, imp_{np}^{-FR}, the destination-n/product-p log import from all countries except France, and $\overline{imp_{p,t}^{-FR}}$ the product-level average value of the log import across all other destinations. With this specification, we avoid including the component of demand in any given product-destination that might be driven by potential productivity shocks to all French exporters. Our key identification assumption is that the variations in value of the demand shock are uncorrelated with firm-level residual ν_{it}'s in Equation (1) of the main paper.

To construct the instruments, we use the French customs data that provides the value of the exports of firms by destination and product (at the nc8 level) spanning the 1995-2007 period. The data allows us to compute the share of each destination-n/product-p share of firm-i exports ($\Lambda_{inp,0}$) as the corresponding average for years 1995 and 1996. To build the product-level demand shocks $\left(imp_{np,t}^{-FR} - \overline{imp_{p,t}^{-FR}} \right)$, we rely on the COMTRADE bilateral Trade Flows Data, and in particular on the harmonized version of the data provided in the BACI dataset. This dataset includes the values of flows from each exporter to each importing destination as HS6 code product-level.[18] We use this information to compute for each product in each destination country the sum of all imports from all other countries, leaving out France. We construct the instrument ds_{it}^{P} for years 1997-2007.

OA.2.9.2 Bartik-style Instruments

As discussed in Section 4.2.2 of the main paper, we also construct an instrument for the price of IT relative to local wages that follows the standard logic of Bartik (1991), relying

[18] We use the concordance procedure made available by Van Beveren et al. (2012b) to map CN8 products code over time, and to more aggregated HS6 product codes.

on local variations on the industrial composition of employment. We create a measure of the predicted change in the labor demand in each employment area, based on the interaction of the initial composition of the wage bill in each employment area and the change in each industry's employment at the national level. Let ν_{nj0} denote the share of employment of region n in 2-digit industry j in 1990, and let $\overline{L}_{jt}$ denote the share of that industry in the national wage bill. We then define the instrument z_{nt} for region n at time t as[19]

$$z_{nt} \equiv \sum_{j} \nu_{nj0} \times \log \overline{L}_{jt}. \tag{OA.2.7}$$

[19] Figures OA.12 and Table OA.10 provide an illustration for how this instrument helps identify the elasticity of substitution σ.

OA.3 Details on the Micro-Level Reduced-Form Facts

In this section, we provide additional results on the relationship between relative IT demand and firm scale, complementing the results of Section 2 and Appendix B in the main paper.

OA.3.1 Details on the Within-Industry Results

OA.3.1.1 Measures of Relative IT Demand

In the main text, we specifically consider the case of IT demand relative to the number of employees. This measure is the ratio of the investment/stock of software/hardware to the average of the number of workers employed by the firm at the end of each quarter (excluding temporary workers). Additionally, we construct alternative measures of IT demand per unit of labor as follows. In the numerator, we consider the payments to software or hardware, i.e., the product of the stock and the corresponding measure of user cost. In the denominator, we use the number of hours or the wage bill.

In additional analyses, we define for each firm in each year the following other measures of IT demand *relative* to other inputs.

IT demand per unit of capital is the ratio of the investment/stock of software/hardare to investment/stock of capital (in 1000s of euros). IT demand per unit of costs is similarly constructed relative to the sum of investment in capital and wage bill, or relative to the sum total of all factor payments.

We use the observed values of investment (rather than accumulated stocks) as alternative measures for non-labor inputs to ensure that the results are not driven by the process of the construction of the stock measures.

OA.3.1.2 Results for Alternative Measures of Relative IT Demand

Table OA.3 expands on the results presented in Table 1 in the main text by considering alternative measures of relative IT demand. Columns 3-4 consider IT factor payments relative to the wage bill, instead of the number of workers, and Columns 7-8 consider the ratio of IT per unit of tangible capital. The coefficients remain sizable, significant, and comparable with our main measures of intensity in every case.

Table OA.3: Regressions of Log Relative IT Demand on Log Firm Size

	IT per Unit of Labor				IT per Unit of Capital				IT per Unit of Cost	
	Workers	Workers	Wage Bill	Wage Bill	Total	Total	Tangible	Tangible	Costs	Costs
Panel 1: Software (Stock)										
Size (proxied by sales)	0.3688		0.3151		0.2807		0.2860		0.3033	
	(0.0031)		(0.0030)		(0.0032)		(0.0032)		(0.0030)	
Size (proxied by VA)		0.3499		0.2974		0.2935		0.3005		0.2876
		(0.0033)		(0.0033)		(0.0034)		(0.0034)		(0.0032)
Observations	594,009	594,104	593,995	594,095	547,292	547,355	546,410	546,472	594,079	594,182
R2	0.244	0.240	0.233	0.229	0.239	0.239	0.240	0.239	0.236	0.233
Panel 1: Software (Investment)										
Size (proxied by sales)	20.2336		0.4983		4.3970		5.2124		0.4245	
	(0.1046)		(0.0028)		(0.0272)		(0.0341)		(0.0024)	
Size (proxied by VA)		20.8305		0.5142		4.7130		5.6050		0.4368
		(0.1105)		(0.0030)		(0.0287)		(0.0360)		(0.0026)
Observations	1,177,293	1,177,490	1,177,325	1,177,526	1,158,549	1,158,739	1,147,751	1,147,910	1,177,950	1,178,148
R2	0.090	0.089	0.084	0.082	0.081	0.082	0.075	0.076	0.082	0.081
Panel 1: Hardware (Stock)										
Size (proxied by sales)	0.2664		0.2062		0.2134		0.2256		0.2025	
	(0.0007)		(0.0007)		(0.0008)		(0.0008)		(0.0007)	
Size (proxied by VA)		0.2027		0.1321		0.1710		0.1865		0.1312
		(0.0008)		(0.0008)		(0.0009)		(0.0009)		(0.0008)
Observations	2,929,990	2,930,210	2,929,984	2,930,381	2,842,300	2,842,532	2,843,134	2,843,281	2,931,093	2,931,455
R2	0.423	0.411	0.387	0.376	0.422	0.417	0.454	0.448	0.350	0.339
Panel 1: Hardware (Investment)										
Size (proxied by sales)	41.1108		0.8824		17.2867		19.8968		0.7492	
	(0.1803)		(0.0051)		(0.0562)		(0.0699)		(0.0037)	
Size (proxied by VA)		32.3492		0.6012		15.8463		18.3580		0.5454
		(0.1854)		(0.0052)		(0.0578)		(0.0719)		(0.0038)
Observations	4,451,987	4,452,704	4,450,990	4,451,843	4,478,768	4,479,477	4,409,937	4,410,454	4,456,254	4,457,018
R2	0.164	0.160	0.138	0.135	0.185	0.182	0.240	0.237	0.147	0.143

Note: In panels 2 and 4, the dependent variable is IT investment per unit of labor, capital, and cost and in panels 1 and 3 it is the logarithm of IT stock per unit of labor, capital and cost. Standard errors are reported in brackets. In columns (1)-(4) we report results of IT per unit of labor, in columns (5)-(8) we report results for IT per unit of capital, and in columns (9) and (10) we report results of IT per unit of cost. The independent variable is the logarithm of firm size either proxied by sales or value added. The time period is 1995-2007. In panels 1 and 2 the sample is all firms sampled by EAE, and in panels 3 and 4, the sample is BRN firms. All columns include a full set of 3-digit industry classification fixed effects interacted with year fixed effects and a full set of cohorts fixed effect (pre-1980, 1980-1993, 1993-1995, ..., 2005-2007) and normalized age fixed effects. For investment intensities semi-elasticities, units matter for interpretation. The units for the IT demand per unit of labor, capital, and cost are euros per worker, euros per thousand euros of capital, and euros per thousand euros of cost, respectively. Imputed values of the "investment" measures are dropped from the analysis. A semi-elasticity of 20.5 of software investment per worker to sales means that raising sales by a factor of 2 raises software per worker by $20.5 \log 2 = 14$ euros. An elasticity of 0.365 of sofware stock per worker to sales means that raising sales by a factor of 2 raises software stock per worker by 36.5%.

OA.3.1.3 Age/Cohort/Year Fixed Effects

As mentioned in the main text regarding specifications (1) and (2) therein, we control for age, cohort, and time fixed effects. However, it is well-known that one cannot jointly identify age, cohort, and year fixed effects due to their collinearity. For this exercise, we apply one of the normalizations suggested by Deaton (2018) and attribute the growth of the dependent variable to year and cohort effects. We then use the age effect to capture

Table OA.4: Regressions of Log Relative IT Demand on Alternative Measures of Firm Size

	IT per Unit of Labor				IT per Unit of Capital				IT per Unit of Cost	
	Workers	Workers	Wage Bill	Wage Bill	Total	Total	Tangible	Tangible	Costs	Costs
Panel 1: Software (Stock)										
Number of plants	0.0015		0.0015		0.0014		0.0016		0.0013	
	(0.0002)		(0.0002)		(0.0002)		(0.0002)		(0.0002)	
Number of occupational layers		0.2634		0.2242		0.2567		0.2604		0.2262
		(0.0047)		(0.0047)		(0.0049)		(0.0049)		(0.0046)
Observations	580,662	580,662	580,811	580,811	535,128	535,128	534,275	534,275	580,850	580,850
R2	0.226	0.230	0.219	0.222	0.228	0.232	0.228	0.232	0.223	0.226
Number of destination countries	0.0277		0.0244		0.0225		0.0231		0.0239	
	(0.0004)		(0.0004)		(0.0004)		(0.0004)		(0.0004)	
Number of products		0.0066		0.0060		0.0055		0.0057		0.0059
		(0.0002)		(0.0002)		(0.0002)		(0.0002)		(0.0002)
Observations	287,740	287,740	288,564	288,564	270,172	270,172	269,947	269,947	288,886	288,886
R2	0.201	0.193	0.194	0.187	0.191	0.185	0.192	0.186	0.197	0.191
Panel 1: Hardware (Stock)										
Number of plants	0.0040		0.0040		0.0036		0.0040		0.0038	
	(0.0001)		(0.0001)		(0.0001)		(0.0001)		(0.0001)	
Number of occupational layers		0.1012		0.0721		0.1120		0.1227		0.0757
		(0.0009)		(0.0009)		(0.0010)		(0.0010)		(0.0009)
Observations	2,811,644	2,811,644	2,813,268	2,813,268	2,732,468	2,732,468	2,733,730	2,733,730	2,813,897	2,813,897
R2	0.396	0.398	0.368	0.369	0.407	0.409	0.437	0.440	0.330	0.331
Number of destination countries	0.0340		0.0302		0.0257		0.0268		0.0294	
	(0.0002)		(0.0002)		(0.0002)		(0.0002)		(0.0002)	
Number of products		0.0084		0.0077		0.0067		0.0069		0.0075
		(0.0001)		(0.0001)		(0.0001)		(0.0001)		(0.0001)
Observations	570,042	570,042	572,530	572,530	562,342	562,342	563,260	563,260	572,502	572,502
R2	0.285	0.264	0.255	0.238	0.314	0.304	0.334	0.324	0.224	0.207

Note: In all panels the dependent variable is the logarithm of IT stock per unit of labor, capital, and cost. Standard errors are reported in brackets. In columns (1)-(4) we report results of IT per unit of labor, in columns (5)-(8) we report results for IT per unit of capital, and in columns (9) and (10) we report results of IT per unit of cost. The time period is 1995-2007. In panel 1 the sample is all firms sampled by EAE, and in panel 2 the sample is BRN firms. All columns include a full set of 3-digit industry classification fixed effects interacted with year fixed effects and a full set of cohorts fixed effect (pre-1980, 1980-1993, 1993-1995, ..., 2005-2007) and normalized age fixed effects. A semi-elasticity of 0.0276 of software stock per worker to the number of destination countries means that exporting to one new country raises software stock per worker by 2.76%.

fluctuations in the dependent variable that average to zero over the life of the firm. In effect, this consists of rewriting the set of age dummies FE_a as $FE^*_a = FE_a - [(a-1)FE_{a=2} - (a-2)FE_{a=1}]$ and performing the estimation laid out in Equation (1) of the main text, excluding all dummies corresponding to the first year, the first cohort, and ages 1 and 2.

Figure OA.11 shows the fixed effects of cohorts for various measures of relative demand. In some cases, there appears to be an upward trend in newer cohorts of firms (e.g., software or hardware demand) but we do not find a robust pattern in terms of IT demand across firms. We also note that our main results do not change with or without including theses cohort/age/year fixed effects.

OA.3.1.4 Hump-Shape Hardware Investment

In Figure 5 of the main text, we find that the relative intensity of hardware investment initially rises but then somewhat falls among the largest firms. We believe this pattern is likely to stem from the fact that our measure of hardware investment includes non-IT related office equipments. The mentioned pattern is largely driven by a group of mid-size firms that report 100% of their total investments in the "office and computing equipment" category, a likely indicator that their investment is in the office and furniture component, rather than IT. When we restrict our analysis to the sample of 38,410 observations for which we are able to distinguish between computing equipment and non-IT office furniture equipment (firms in the agrifood industry sampled in EAE), computing investment relative to total investment or to hardware investment (computing plus office furniture) is increasing in size (see Figure OA.9).

OA.3.1.5 Alternative Measures of Firm Size

In addition to firm output and employment, we further investigate the relationship between a number of other proxies of firm scale and relative IT demand. Firms can expand their scales along different margins: they can sell more of the same products to the same markets, they can sell the same products to more markets, or they can sell more products. The BRN data does not provide us with a decomposition of firm sales along these margins. Instead, we rely on customs data that allows us to gain a partial picture of these different margins in the international markets in the sample of exporting firms. Table OA.4 presents the results of the same regressions as in Table OA.3, where firm size is measured by: 1) the number of international markets (destination countries) and 2) the number of exported products. In both cases, there is a positive relationship between the relative IT demand of the firm and these proxies of the scale of operations of the firm. On average, exporting to a new market is associated with an increase in relative IT demand of around 2% to 3% and exporting a new product with an increase of around 0.5% to 0.8%.

As discussed in Section 6.1 of the main text, we attribute the relationship between firm scale and relative IT demand to the organizational needs that stem from more complex patterns of production as firms expand their scale. Following Caliendo et al. (2015), we rely on DADS data to find suggestive evidence that simple measures of organizational complexity of firms indeed appear to be correlated with relative IT demand. In particular, Table OA.4 also shows a positive relationship between the relative IT demand of the firm and 1) the firm's number of plants and 2) the number of occupational layers. On average, adding a new plant is associated with an increase in the software (hardware) intensity of

Table OA.5: Regressions of Relative IT Demand on Log Firm Size (Within Firm)

	IT per Unit of Labor				IT per Unit of Capital				IT per Unit of Cost	
	Workers	Workers	Wage Bill	Wage Bill	Total	Total	Tangible	Tangible	Costs	Costs
Panel 1: Software (Stock)										
Size (proxied by sales)	0.2138		0.1509		0.3442		0.3594		0.1724	
	(0.0328)		(0.0330)		(0.0338)		(0.0339)		(0.0328)	
Size (proxied by VA)		0.2224		0.1472		0.3395		0.3461		0.1746
		(0.0289)		(0.0290)		(0.0298)		(0.0298)		(0.0290)
Observations	236,510	236,617	236,379	236,434	224,344	224,615	224,730	225,052	236,416	236,461
R2	0.835	0.830	0.830	0.826	0.829	0.824	0.829	0.825	0.831	0.826
Panel 1: Hardware (Stock)										
Size (proxied by sales)	0.2681		0.1743		0.3823		0.3874		0.1932	
	(0.0097)		(0.0098)		(0.0101)		(0.0102)		(0.0096)	
Size (proxied by VA)		0.1520		0.0506		0.2564		0.2597		0.0716
		(0.0082)		(0.0082)		(0.0085)		(0.0085)		(0.0081)
Observations	249,933	250,935	250,921	252,029	246,038	247,031	245,222	246,259	250,436	251,530
R2	0.867	0.866	0.843	0.843	0.905	0.905	0.915	0.915	0.845	0.846

Note: The dependent variable is the logarithm of IT stock per unit of labor, capital, and cost. Standard errors are reported in brackets and are clustered at the level of the firm. In columns (1)-(4) we report results of IT per unit of labor, in columns (5)-(8) we report results for IT per unit of capital, and in columns (9) and (10) we report results of IT per unit of cost. The independent variable is the logarithm of firm size either proxied by sales or value added. The time period is 1995-2007. In panel 1 the sample is all firms sampled by EAE, and in panel 2, the sample is BRN firms. All columns include a full set of firm fixed effects, and 3-digit industry classification fixed effects interacted with year fixed effects. An elasticity of 0.2042 of sofware stock per worker to sales means that raising sales by a factor of 2 raises software stock per worker by 20.42%.

firms by 0.15% (0.40%), while adding an occupational layer with an increase of more than 20% (around 10%).

OA.3.2 Additional Details on the Within-Firms Results

Table OA.5 reports the results of an estimation of the within-firm relationship between relative IT demand and firm size using the same set of alternative proxies for relative IT demand as that considered in our examination of the within-industry relationship in Table OA.3.

OA.3.3 Reduced-Form Identification of the Scale-Dependence in IT Demand

We rely on an instrument for firm size to identify the (within-firm) effect of scale on IT. In this way, we ensure that our positive estimates in Table OA.5 are not driven by potential correlations between firm size and the determinants of the residual ν_{it} in Equation (2), e.g., unobserved IT-biased productivity.[20] To identify the contribution of scale-dependence to

[20]Section OA.5.7 discusses a number of further concerns with the reduced-form identification strategy presented here, which are addressed by the structural identification approach presented in Section 4.2.

Table OA.6: Reduced-Form Identification of the Size Elasticity of Relative IT Demand

	IT per Unit of Labor				IT per Unit of Capital				IT per Unit of Cost	
	Workers	Workers	Wage Bill	Wage Bill	Total	Total	Tangible	Tangible	Costs	Costs
Panel 1: Software (Stock)										
Size (proxied by sales)	0.5623		0.3551		0.4342		0.4988		0.5844	
	(0.3752)		(0.3783)		(0.3721)		(0.3823)		(0.3661)	
Size (proxied by VA)		0.9254		0.4466		0.8518		0.9496		0.7322
		(0.5223)		(0.4999)		(0.5120)		(0.5266)		(0.4888)
Observations	105,113	103,973	105,369	104,230	100,718	99,590	101,057	99,937	105,511	104,352
First stage *F*-stat	222.5	112.0	221.4	117.6	205.3	109.2	203.5	107.3	224.2	118.8
Panel 1: Hardware (Stock)										
Size (proxied by sales)	0.6770		0.4060		0.5344		0.4867		0.0065	
	(0.1354)		(0.1297)		(0.1308)		(0.1275)		(0.1210)	
Size (proxied by VA)		0.9577		0.4632		0.7937		0.7004		-0.0104
		(0.1795)		(0.1837)		(0.1782)		(0.1783)		(0.1684)
Observations	98,673	97,224	99,352	98,497	99,414	98,567	99,571	98,719	99,304	98,468
First stage *F*-stat	260.5	100.8	267.4	103.3	257.1	115.9	264.1	89.5	270.8	110.3

Note: The dependent variable is the logarithm of IT stock per unit of labor, capital, and cost. Standard errors are reported in brackets and are clustered at the level of the firm. In columns (1)-(4) we report results of IT per unit of labor, in columns (5)-(8) we report results for IT per unit of capital, and in columns (9) and (10) we report results of IT per unit of cost. The independent variable is the logarithm of firm size either proxied by sales or value added, instrumented by product demand shocks. The time period is 1997-2007. In panel 1 the sample is all exporting firms sampled by EAE, and in panel 3, the sample is exporting BRN firms. All columns include a full set of 3-digit industry classification fixed effects interacted with year fixed effects. An elasticity of 0.5656 of sofware stock per worker to sales means that raising sales by a factor of 2 raises software stock per worker by 56.56%. Observations are weighted by each firm's share of export in its total sales in 1995-1996.

the correlation between size and relative IT demand, we construct a shift-share instrument for export demand shocks, interacting initial firm-level shares of exports (in 1995) with the evolution of relative demand across destinations/products. The logic is that demand shocks to export destinations are orthogonal to firm-level productivity shocks, and thus provide an exogenous source of variation in firm size. This idea has recently been used in a wide range of empirical applications (e.g., Hummels et al., 2014; Mayer et al., 2015; Aghion et al., 2017; Garin and Silveiro, 2017; Panon, 2019). Section OA.2.9.1 of the Online Appendix provides further details about the construction of this instrument.

Since the definition of the instrument relies on information on the composition of firm exports, we limit our attention to the sample of exporting firms. Table OA.16 compares the summary statistics of this sample with the sample of all firms. As is well-known, exporting firms are typically larger than other firms. The table shows that they are, in addition, also slightly more IT intensive than average firms (Fort et al., 2017).

Table OA.6 presents the results of applying the following specification in the sample of exporting firms

$$rel.\,IT\,demand_{it} - \overline{rel.\,IT\,demand}_t = \eta\left(\log Size_{it} - \overline{\log Size}_i\right) + FE_{kt} + \nu_{it}, \qquad \text{(OA.3.1)}$$

Table OA.7: Reduced-Form Identification of the Size Elasticity of Relative IT Demand (Unweighted)

	IT per Unit of Labor				IT per Unit of Capital				IT per Unit of Cost	
	Workers	Workers	Wage Bill	Wage Bill	Total	Total	Tangible	Tangible	Costs	Costs
Panel 1: Software (Stock)										
Size (proxied by sales)	1.2791		0.6703		1.0987		1.1197		0.9357	
	(0.3830)		(0.3768)		(0.3776)		(0.3806)		(0.3738)	
Size (proxied by VA)		1.5635		0.7303		1.2679		1.3100		1.0789
		(0.4911)		(0.4809)		(0.4751)		(0.4826)		(0.4785)
Observations	105,579	104,408	105,845	104,671	101,144	99,980	101,475	100,326	105,987	104,791
First stage F-stat	406.7	223.8	423.8	229.4	432.0	238.7	421.6	232.0	423.9	231.8
Panel 1: Hardware (Stock)										
Size (proxied by sales)	1.5248		1.0663		1.1005		1.0712		0.1791	
	(0.1264)		(0.1171)		(0.1173)		(0.1148)		(0.1049)	
Size (proxied by VA)		1.9228		1.3228		1.4229		1.3646		0.2618
		(0.1828)		(0.1597)		(0.1603)		(0.1569)		(0.1329)
Observations	99,294	98,353	99,982	99,110	100,005	99,142	100,175	99,309	99,944	99,086
First stage F-stat	420.9	223.5	415.8	224.1	411.1	220.6	421.6	223.4	418.8	227.2

Note: The dependent variable is the logarithm of IT stock per unit of labor, capital, and cost. Standard errors are reported in brackets and are clustered at the level of the firm. In columns (1)-(4) we report results of IT per unit of labor, in columns (5)-(8) we report results for IT per unit of capital, and in columns (9) and (10) we report results of IT per unit of cost. The independent variable is the logarithm of firm size either proxied by sales or value added, instrumented by product demand shocks. The time period is 1997-2007. In panel 1 the sample is all exporting firms sampled by EAE, and in panel 3, the sample is exporting BRN firms. All columns include a full set of 3-digit industry classification fixed effects interacted with year fixed effects. An elasticity of 1.3035 of sofware stock per worker to sales means that raising sales by a factor of 2 raises software stock per worker by 130.35%.

where, as before, $rel.\,IT\,demand_{it}$ denotes a measure of the relative demand for IT inputs for a firm i in an industry k at time t, FE_{kt} stands for a flexible set of industry-time fixed effects (at the 3-digit level), $Size_{it}$ is the sales or value added of the firm (depending on the specification), and $\overline{\log Size_i}$ is the firm-level mean of log firm size. We estimate Equation (OA.3.1) with 2SLS, using the shocks defined in Equation (OA.2.6) as instruments for log firm size. Estimates are weighted by each firm's initial share of exports in its total sales. This method gives less weight to firms for which exports constitute a very small share of sales (see e.g. Aghion et al., 2017). Results are provided with product demand shocks from 1997 to 2007.

The coefficients are positive and significant for the majority of specifications. They are also close in magnitude to, even if larger than, those reported in Table OA.5 for the within-firm effects. Note that the sample of firms in Table OA.6 is much smaller, only featuring relatively large exporting firms for which we can construct the instrument. Table OA.7 presents the unweighted estimates. The unweighted results are typically larger in both magnitude of the estimates and the standard errors. This should not come as a surprise since exports constitute a smaller share of the output of the smaller firms, and our instrument is thus less powerful among these firms.

Comparison with the Structural Identification of Section 4.2

The reduced-form identification strategy presented above has some disadvantages compared to the structural identification strategy we present in Section 4.2 of the main paper for uncovering the same elasticity. First, the sample of exporting firms is much smaller than the sample of all firms, mainly due to the fact that most exporting firms belong to the manufacturing sector. Our structural identification can be applied in a much broader sample of French firms. Section OA.5.7 of the Online Appendix discusses a number of further concerns with the reduced-form identification strategy presented here, which are addressed by the structural identification approach.

To facilitate a direct comparison between the two approaches, Section OA.5.2 provides an illustration of the logic of the identification under our structural approach. In particular, Section OA.5.2.2 specifically focuses on the idea behind the identification of the scale-dependence parameter. Using the ideas developed in these section, Section OA.5.2.3 then provides a direct comparison of the identification of the scale-dependence parameter using the structural IV and the export-based shift-share IV used in this section. Therein, we show that both IVs lead to similar estimates for the scale-dependence parameter.

OA.4 Additional Theoretical Results

OA.4.1 Fixed-Cost Models for IT

We note that the specification of production functions with scale-dependent IT demand is conceptually similar to one in a model involving a fixed-cost of IT adoption. A model with fixed costs may generate both the scale-dependent IT demand and the negative relationship between size and scale elasticity. However, it also implies that both relationships vanish as firms grow large. Table 5 in Appendix B.2 in the main text shows that the correlation between software intensity and firm size robustly holds across different brackets of firm size. This finding suggests a specification of relative IT demand with an output elasticity η that is constant in firm size. The nhCES production function predicts exactly this pattern with $\eta = (1 - \sigma)\,\epsilon$. Thus, our model is better suited for a *quantitative* account of the observed patterns compared to a the fixed-cost model. That said, we note that one can conceptualize scale-dependent IT demand as the result of many successive levels of fixed costs of IT adoption that grow with the scale.

For completeness, this section lays out two alternative production functions in which IT adoption includes fixed costs: one in units of IT inputs and the other in units of non-IT inputs. As we discuss below, each model is in line with a distinct argument about the nature of IT adoption. In both cases, we show that the model indeed leads to the same core predictions as that from our production function, i.e., the scale-dependence of IT demand, complementarity between IT and non-IT inputs, and a cross-sectional link between firm size and returns to scale. However, we find that our micro-level evidence on the relationship between size and IT intensity, on the *intensive margin*, is only in line with the second model in which the fixed adoption costs are paid in units of non-IT inputs. In addition, we show that the implied patterns of scale-dependence in both models vanish among large firms, which is different from what we find in our data.

Finally, in Section OA.4.1.3 below, we provide an alternative microfoundation for scale-dependent IT demand, in which firms have alternative homothetic recipes for producing their output that involve some fixed costs. This approach differs from that presented in Appendix A.3 in the main text, in which recipes do not involve fixed costs but are instead heterogeneous in terms of their returns to scale.

OA.4.1.1 IT Adoption with Fixed IT Costs

IT is typically associated with a technology with large fixed costs and small marginal costs. It could be argued that this idea is more in line with the technology of IT *production*, rather than for the *use* of IT in production of other outputs, which is the focus of our facts. However, as we will see below, such a model has the counterfactual prediction that the elasticity of IT intensity with respect to firm size is negative on the *intensive* margin.

Consider the following fixed-cost-of-IT production function $Y = Z\mathcal{F}(X_N, X_I)$ defined as

$$Y = \begin{cases} ZX_N, & X_I = 0, \\ \Delta_I Z \left(\frac{X_I - \psi_I}{\xi}\right)^{\xi} \left(\frac{X_N}{1-\xi}\right)^{1-\xi}, & X_I > 0, \end{cases}$$

where ψ_I and Δ_I are constants that captures the fixed cost of adopting IT (in units of IT inputs) and its corresponding productivity premium, respectively. In order for IT to be adopted by some firms, assume that $\Delta_I > W^{\xi}$, where W is the relative price of IT inputs. We can then show that the cost function is given by

$$\mathcal{C}(Y) = \begin{cases} \frac{Y}{Z}, & Y \leq Y^*, \\ W\psi_I + \frac{W^{\xi}}{\Delta_I}\frac{Y}{Z}, & Y \geq Y^*, \end{cases}$$

where $Y^* = ZW\psi_I / \left(1 - W^{\xi}/\Delta_I\right)$ denotes the cutoff of firm size above which firms adopt nonzero IT inputs. Accordingly, the share of IT in total costs is given by

$$\Omega = \frac{WX_I}{\mathcal{C}(Y)} = \begin{cases} 0, & Y \leq Y^*, \\ \frac{\xi + \psi_I \Delta_I W^{1-\xi}\frac{Z}{Y}}{1+\psi_I \Delta_I W^{1-\xi}\frac{Z}{Y}}, & Y \geq Y^*, \end{cases}$$

which *decreases* from $1 - \frac{1-\xi}{\Delta_I W^{-\xi}}$ to ξ as the size Y goes from Y^* to infinity. We find scale-dependent IT demand, but the share of IT in costs indeed falls with size among firms that do invest in IT. The positive relationship between IT and size only appears on the extensive margin here.

We can characterize the output elasticity of relative demand and the elasticity of substitution between IT and non-IT inputs as follows. First, we calculate the the elasticity of relative demand with respect to output for $Y \geq Y^*$:

$$\frac{\partial \log\left(WX_I/X_N\right)}{\partial \log Y} = \frac{\partial \log}{\partial \log Y}\left(\frac{\xi}{1-\xi} + \frac{\psi_I}{1-\xi}W^{1-\xi}\Delta_I \frac{Z}{Y}\right) = -\frac{\psi_I W^{1-\xi}\Delta_I \frac{Z}{Y}}{\xi + \psi_I W^{1-\xi}\Delta_I \frac{Z}{Y}} < 0.$$

This shows that the IT intensity is increasing in firm size on the extensive margin, but is decreasing in firm size on the intensive margin. The elasticity above converges to zero as Y goes to infinity. Next, we derive the elasticity of substitution between IT and non-IT inputs

$$-\frac{\partial\log\left(X_I/X_N\right)}{\partial\log W}=1-\frac{\partial\log}{\partial\log W}\left(\frac{\xi}{1-\xi}+\frac{\psi_I}{1-\xi}W^{1-\xi}\Delta_I\frac{Z}{Y}\right)=1-(1-\xi)\frac{\psi_I W^{1-\xi}\Delta_I\frac{Z}{Y}}{\xi+\psi_I W^{1-\xi}\Delta_I\frac{Z}{Y}}<1,$$

which we find to be less than unity.

Finally, let us examine the returns to scale properties of the production function. First, the production function features increasing returns to scale for $Y \geq Y^*$. Second, the scale elasticity is decreasing in size for $Y \geq Y^*$, as its reciprocal the cost elasticity is given by

$$\mathcal{E}\left(Y\right)=\frac{\partial\log\mathcal{C}\left(Y\right)}{\partial\log Y}=\frac{1}{1+\psi_I\Delta_I W^{1-\xi}\frac{Z}{Y}},$$

and increases from W^{ξ}/Δ_I to 1 as Y goes from Y^* to infinity. Thus, returns to scale is decreasing in firm size.

OA.4.1.2 IT Adoption with Fixed non-IT Costs

It is often argued that adoption of IT requires fixed complementary investments, e.g., in organizational and managerial aspects of the firm. One may argue that such investments can be construed as fixed costs in units of non-IT inputs.

Consider the following fixed-cost-of-IT production function $Y = Z\mathcal{F}\left(X_N, X_I\right)$ defined as

$$Y=\begin{cases} ZX_N, & X_I=0,\\ \Delta_I Z\left(\frac{X_I}{\xi}\right)^{\xi}\left(\frac{X_N-\psi_N}{1-\xi}\right)^{1-\xi}, & X_I>0,\end{cases}$$

where ψ_N and Δ_I are constants that captures the fixed cost of adopting IT (in units of non-IT inputs) and its corresponding productivity premium, respectively. In order for IT to be adopted by some firms, assume that $\Delta_I > W^{\xi}$, where W is the relative price of non-IT inputs. We can then show that the cost function is given by

$$\mathcal{C}\left(Y\right)=\begin{cases}\frac{Y}{Z}, & Y\leq Y^*,\\ \psi_N+\frac{W^{\xi}}{\Delta_I}\frac{Y}{Z}, & Y\geq Y^*,\end{cases}$$

where $Y^* = Z\psi_N/\left(1-W^{\xi}/\Delta_I\right)$, denotes the threshold of firm size above which firms adopt nonzero IT inputs. Accordingly, the share of IT in total costs is given by

$$\Psi = \frac{WX_I}{\mathcal{C}(Y)} = \begin{cases} 0, & Y \leq Y^*, \\ \frac{\xi}{1+\psi_N \frac{\Delta_I}{W^\xi} \frac{Z}{Y}}, & Y \geq Y^*, \end{cases}$$

which increases from $\Delta_I W^{-\xi}\xi$ to ξ as the size Y goes from Y^* to infinity.

We can characterize the output elasticity of relative demand and the elasticity of substitution between IT and non-IT inputs as follows. First, we calculate the the elasticity of relative demand with respect to output:

$$\frac{\partial \log(X_I/X_N)}{\partial \log Y} = \frac{\partial \log}{\partial \log Y}\left(\frac{\xi/W}{1-\xi+\psi_N \frac{\Delta_I}{W^\xi}\frac{Z}{Y}}\right) = \frac{1}{1+(1-\xi)\frac{W^\xi}{\psi_N \Delta_I}\frac{Y}{Z}} > 0.$$

This shows that the IT intensity is increasing in firm size both on the extensive and the intensive margins. However, this elasticity converges to zero as Y goes to infinity. Next, we derive the elasticity of substitution between IT and non-IT inputs

$$-\frac{\partial \log(X_I/X_N)}{\partial \log W} = -\frac{\partial \log}{\partial \log W}\left(\frac{\xi/W}{1-\xi+\psi_N \frac{\Delta_I}{W^\xi}\frac{Z}{Y}}\right) = 1 - \frac{1}{1+(1-\xi)\frac{W^\xi}{\psi_N \Delta_I}\frac{Y}{Z}},$$

which we find to be less than unity. Thus, in line with our estimates for the case of the nhCES production function, we find a positive elasticity of IT intensity with respect to firm size as well as gross complementarity between the two inputs.

Finally, let us examine the returns to scale properties of the production function. First, the production function features increasing returns to scale for $Y \geq Y^*$. Second, the scale elasticity is decreasing in size for $Y \geq Y^*$, as its reciprocal the cost elasticity is given by

$$\mathcal{E}(Y) = \frac{\partial \log \mathcal{C}(Y)}{\partial \log Y} = \frac{1}{1+\psi_N \frac{\Delta_I}{W^\xi}\frac{Z}{Y}},$$

and increases from W^ξ/Δ_I to 1 as Y goes from Y^* to infinity.

OA.4.1.3 Micro-foundations of Nonhomothetic Production Functions using Fixed Costs

Finally, we offer an alternative to the microfoundation for scale-dependence in firm-level technology provided in Appendix A.3 of the main text that relies on fixed costs. Assume that the firm i has access to a collection $\mathcal{I}_i$ of different recipes to produce output Y_i by combining non-IT input X_{Ni} and IT input X_{Ii}. The outputs of different receipes are perfectly substitutable.

Let us assume that the cost function for recipe $\omega \in \mathcal{I}_i$ with output y_ω is given by $C_\omega = (a_\omega + b_\omega W)\left(\psi_\omega + y_\omega^\zeta\right)$ with $\zeta > 1$ where ψ_ω is a recipe-specific fixed cost. Defining $c_\omega \equiv a_\omega + b_\omega W$, we find that the allocation of output across recipes follows $y_\omega = Y_i \left(\frac{c_\omega}{\bar{c}_i}\right)^{-\frac{1}{\zeta-1}}$ where $\bar{c}_i^{-\frac{1}{1-\zeta}} \equiv \int_{\mathcal{I}_i} c_\omega^{-\frac{1}{1-\zeta}} d\omega$ is a firm-specific function of relative IT price W. The cost elasticity of recipe ω is the given by

$$\mathcal{E}_\omega = \frac{1}{1 + \psi_\omega y_\omega^{-\zeta}} = \frac{\zeta}{1 + \psi_\omega \left(\frac{c_\omega}{\bar{c}_i}\right)^{\frac{\zeta}{\zeta-1}} Y_i^{-\zeta}}.$$

The firm-level cost function and the cost elasticity satisfy $C_i = \bar{c}_i\left(\overline{\psi}_i + Y_i^\zeta\right)$ and $\mathcal{E}_i = \frac{\zeta}{1+\overline{\psi}_i Y^{-\zeta}}$ where we have defined $\overline{\psi}_i \equiv \int_{\mathcal{I}_i}\left(\frac{c_\omega}{\bar{c}_i}\right)\psi_\omega d\omega$. Let $\widehat{\psi}_\omega \equiv \psi_\omega c_\omega^{\frac{\zeta}{\zeta-1}}$, we have:

$$\begin{aligned}
\overline{\psi}_i &\equiv \int_{\mathcal{I}_i}\left(\frac{c_\omega}{\bar{c}_i}\right)\psi_\omega d\omega, \\
&= \int_{\mathcal{I}_i}\left(\frac{c_\omega}{\bar{c}_i}\right)^{\frac{1}{1-\zeta}} \psi_\omega \left(\frac{c_\omega}{\bar{c}_i}\right)^{\frac{\zeta}{\zeta-1}} d\omega, \\
&= \bar{c}_i^{\frac{\zeta}{1-\zeta}} \mathbb{E}_i^r\left[\widehat{\psi}_\omega\right].
\end{aligned}$$

This allows us to write $C_i = \bar{c}_i^{\frac{1}{1-\zeta}} \mathbb{E}_i^r\left[\widehat{\psi}_\omega\right] + \bar{c}_i Y_i^\zeta$, and

$$\mathcal{E}_i = \frac{\zeta}{1 + \bar{c}_i^{\frac{\zeta}{1-\zeta}} Y_i^{-\zeta}\widehat{\psi}_\omega}.$$

Letting $\overline{\Omega}_i \equiv \int_{\mathcal{I}_i}\left(\frac{c_\omega}{\bar{c}_i}\right)^{-\frac{1}{\zeta-1}} \Omega_{I,\omega} d\omega = \mathbb{E}_i^r\left[\Omega_\omega\right] = \frac{\partial \log \bar{c}_i}{\partial \log W}$, we can express the firm-level IT cost share as

$$\Omega_{I,i} = \frac{\bar{c}_i^{\frac{1}{1-\zeta}} \mathbb{E}_i^r\left[\widehat{\psi}_\omega \Omega_{I,\omega}\right] + \bar{c}_i \mathbb{E}_i^r\left[\Omega_\omega\right] Y_i^\zeta}{\bar{c}_i^{\frac{1}{1-\zeta}} \mathbb{E}_i^r\left[\widehat{\psi}_\omega\right] + \bar{c}_i Y_i^\zeta},$$

since we have

$$\int_{\mathcal{I}_i} \left(\frac{c_\omega}{\overline{c}_i}\right) \psi_\omega \Omega_\omega d\omega = \int_{\mathcal{I}_i} \left(\frac{c_\omega}{\overline{c}_i}\right)^{\frac{1}{1-\zeta}} \psi_\omega \left(\frac{c_\omega}{\overline{c}_i}\right)^{\frac{\zeta}{\zeta-1}} \Omega_\omega d\omega,$$
$$= \overline{c}_i^{\frac{\zeta}{1-\zeta}} \mathbb{E}_i^r \left[\widehat{\psi}_\omega \Omega_{I,\omega}\right].$$

Thus, firm-level output elasticity of relative demand is given by

$$\begin{aligned}
\eta_i &= \frac{1}{1-\Omega_{I,i}} \frac{\partial \log \Omega_{I,i}}{\partial \log Y}, \\
&= \frac{\zeta \overline{c}_i Y_i^\zeta}{1-\Omega_{I,i}} \left(\frac{\mathbb{E}_i^r \left[\Omega_\omega\right]}{\overline{c}_i^{\frac{1}{1-\zeta}} \mathbb{E}_i^r \left[\widehat{\psi}_\omega \Omega_{I,\omega}\right] + \overline{c}_i \mathbb{E}_i^r \left[\Omega_\omega\right] Y_i^\zeta} - \frac{1}{\overline{c}_i^{\frac{1}{1-\zeta}} \mathbb{E}_i^r \left[\widehat{\psi}_\omega\right] + \overline{c}_i Y_i^\zeta} \right), \\
&= \frac{\zeta \overline{c}_i Y_i^\zeta}{1-\Omega_{I,i}} \frac{\mathbb{E}_i^r \left[\Omega_\omega\right] \left(\overline{c}_i^{\frac{1}{1-\zeta}} \mathbb{E}_i^r \left[\widehat{\psi}_\omega\right] + \overline{c}_i Y_i^\zeta\right) - \left(\overline{c}_i^{\frac{1}{1-\zeta}} \mathbb{E}_i^r \left[\widehat{\psi}_\omega \Omega_{I,\omega}\right] + \overline{c}_i \mathbb{E}_i^r \left[\Omega_\omega\right] Y_i^\zeta\right)}{\left(\overline{c}_i^{\frac{1}{1-\zeta}} \mathbb{E}_i^r \left[\widehat{\psi}_\omega \Omega_{I,\omega}\right] + \overline{c}_i \mathbb{E}_i^r \left[\Omega_\omega\right] Y_i^\zeta\right) \left(\overline{c}_i^{\frac{1}{1-\zeta}} \mathbb{E}_i^r \left[\widehat{\psi}_\omega\right] + \overline{c}_i Y_i^\zeta\right)}, \\
&= -\frac{\zeta \overline{c}_i Y_i^\zeta}{1-\Omega_{I,i}} \frac{\overline{c}_i^{\frac{1}{1-\zeta}} \left(\mathbb{E}_i^r \left[\widehat{\psi}_\omega \Omega_{I,\omega}\right] - \mathbb{E}_i^r \left[\widehat{\psi}_\omega\right] \mathbb{E}_i^r \left[\Omega_\omega\right]\right)}{\left(\overline{c}_i^{\frac{1}{1-\zeta}} \mathbb{E}_i^r \left[\widehat{\psi}_\omega \Omega_{I,\omega}\right] + \overline{c}_i \mathbb{E}_i^r \left[\Omega_\omega\right] Y_i^\zeta\right) \left(\overline{c}_i^{\frac{1}{1-\zeta}} \mathbb{E}_i^r \left[\widehat{\psi}_\omega\right] + \overline{c}_i Y_i^\zeta\right)}.
\end{aligned}$$

This elasticity is positive if there is a negative covariance of recipe-level IT intensities and normalized fixed costs.

OA.4.2 Response to IT Shocks with A Gross Production Function

Consider a setting where one of the non-IT factors $j = M$, is the material intermediate input with a variable supply, sourced through the final good such that the aggregate supply $\overline{X}_M$ of materials and the aggregate consumption $\overline{Y}$ satisfy

$$\overline{X}_M + \overline{Y} = \left(\int Y_i^{\frac{\lambda-1}{\lambda}} di\right)^{\frac{\lambda}{\lambda-1}}. \tag{OA.4.1}$$

We assume a CRS aggregate bundle of all the *other* non-IT and non-material inputs $\mathcal{X}_O(\cdot)$ such that the aggregate bundle of non-IT inputs is given by

$$\mathcal{X}_N\left(X_{M,i}, \boldsymbol{X}_{-IM,i}\right) \equiv \mathcal{G}\left(X_{M,i}, \mathcal{X}_O\left(\boldsymbol{X}_{-IM,i}\right)\right), \tag{OA.4.2}$$

where $\mathcal{G}(\cdot,\cdot)$ is a CRS aggregator of material and all the other non-IT/material factors. Let W_M be the price of materials, and define $\mathcal{C}^N(X_N;\boldsymbol{W}_{-I})$ as the cost function corresponding to the aggregator $\mathcal{X}_N$, and define the material intensity of non-IT inputs Ω_M^N and the elasticity of substitution for materials within the bundle of non-IT inputs σ_M^N as

$$\Omega_M^N \equiv \frac{\partial \log \mathcal{C}^N}{\partial \log W_M}, \qquad 1-\sigma_M^N \equiv \frac{1}{1-\Omega_M^N}\frac{\partial \log \Omega_M^N}{\partial \log W_M}.$$

Let $X_{O,i} \equiv \mathcal{X}_O(\boldsymbol{X}_{-IM,i})$ denote the aggregate bundle of inputs other than IT and materials and $\overline{FS}_O$ stand its corresponding share in aggregate income (revenues) of final good producers. The following proposition characterizes the responses of output and the share of factors other than IT and materials in firm revenues to a fall in IT prices to the first order of approximation.

Proposition OA.4.1. *Assume firm-level technology satisfies condition (24) in the main text as well as the condition (OA.4.2) above, and consider a shock to the relative price of IT inputs W_I that leaves the firm-level technologies and the aggregate supply of all non-IT factors (other than materials) unchanged. To the first order of approximation in the change in the IT price shock, the resulting impact on the aggregate output and on the income share of non-IT inputs are given by*

$$\frac{d\log \overline{Y}}{d\log W_I} = -\frac{\overline{\Omega}_I\left(\overline{\sigma}_I + \Omega_M^N\cdot\overline{\Xi}\cdot\left(1+\frac{\overline{\Omega}_N}{\overline{\mathcal{E}}}\overline{\eta}_I\right)\right)}{\overline{\mathcal{E}}-\overline{\Omega}_I\overline{\eta}_I-\overline{\mathcal{E}}^m\cdot\Omega_M^N\cdot\overline{\Xi}}, \tag{OA.4.3}$$

$$\frac{d\log \overline{FS}_O}{d\log W_I} = \frac{1}{1-\left(1-\frac{\overline{\Omega}_I}{\overline{\mathcal{E}}}\overline{\eta}_I\right)\overline{\Omega}_M}\left[\left(1+\overline{\mathcal{E}}^m-\left(1-\frac{\overline{\Omega}_I}{\overline{\mathcal{E}}}\overline{\eta}_I\right)\overline{\Omega}_M\right)\frac{\overline{\Omega}_I\left(\overline{\sigma}_I+\Omega_M^N\cdot\overline{\Xi}\cdot\left(1+\frac{\overline{\Omega}_N}{\overline{\mathcal{E}}}\overline{\eta}_I\right)\right)}{\overline{\mathcal{E}}-\overline{\Omega}_I\overline{\eta}_I-\overline{\mathcal{E}}^m\cdot\Omega_M^N\cdot\overline{\Xi}}-1-\frac{\overline{\Omega}_N}{\overline{\mathcal{E}}}\overline{\eta}_I\right], \tag{OA.4.4}$$

where $\overline{\Xi}$ is given by

$$\overline{\Xi} \equiv \frac{\overline{\Omega}_N-\overline{\Omega}_I(\overline{\sigma}_I-1)+\sigma_M^N-1}{1-\left(1-\frac{\overline{\Omega}_I}{\overline{\mathcal{E}}}\overline{\eta}_I\right)\overline{\Omega}_M}.$$

Proof. Let W_N denote the price index corresponding to the aggregator $\mathcal{X}_N(\boldsymbol{X}_{-I})$ and let $\overline{X}_N \equiv \mathcal{X}_N(\overline{\boldsymbol{X}}_{-I})$ denote the aggregate bundle of non-IT inputs. A change in the aggregate supply $\overline{X}_I$ of IT inputs in this setting leads to a change in the relative IT prices W_I, which in turn affects the price of materials and the bundle of non-IT inputs. But we can still normalize the price of the bundle of other inputs $W_O \equiv 1$.

By definition, the share of non-IT inputs in aggregate income is given by $\overline{FS}_O = \frac{W_O\overline{X}_O}{\overline{P}\,\overline{Y}}$.

Since we have normalized the price of other inputs to unity and since their supplies remains unaffected by the shock, we find:

$$\frac{d\log\overline{Y}}{d\log W_I} = -\frac{d\log\overline{P}}{d\log W_I} - \frac{d\log\overline{FS}_O}{d\log W_I}. \tag{OA.4.5}$$

Using the relation $\overline{FS}_O = \frac{\overline{\Omega}_N}{\mu\overline{\mathcal{E}}}\left(1-\Omega_M^N\right)$, we can write:

$$\frac{d\log\overline{FS}_O}{d\log W_I} = \frac{d\log\overline{\Omega}_N}{d\log W_I} + \frac{d\log\left(1-\Omega_M^N\right)}{d\log W_I} - \frac{d\log\overline{\mathcal{E}}}{d\log W_I}.$$

We first start with the response of the intensity of non-IT inputs $\overline{\Omega}_N$:

$$\begin{aligned}\frac{d\log\overline{\Omega}_N}{d\log W_I} &= \frac{\partial\log\overline{\Omega}_N}{\partial\log W_I}\left(1-\frac{d\log W_N}{d\log W_I}\right) + \frac{\partial\log\overline{\Omega}_N}{\partial\log\overline{Y}}\cdot\frac{d\log\overline{Y}}{d\log W_I},\\ &= \overline{\Omega}_I\left(\overline{\sigma}_I-1\right)\left(1-\Omega_M^N\cdot\frac{d\log W_M}{d\log W_I}\right) - \overline{\Omega}_I\overline{\eta}_I\cdot\frac{d\log\overline{Y}}{d\log W_I},\end{aligned}$$

where we have used the fact that since $\mathcal{X}_N$ is CRS, by Shephard's lemma, the change in its unit cost is given by to the first order by the chance in the price of material goods times the share of materials in the bundle of non-IT inputs, and where we have also used

$$\begin{aligned}\frac{\partial\overline{\Omega}_N}{\partial\log W_I} &= -\frac{\partial\overline{\Omega}_I}{\partial\log W_I} = \overline{\Omega}_N\overline{\Omega}_I\left(\overline{\sigma}_I-1\right),\\ \frac{\partial\overline{\Omega}_N}{\partial\log\overline{Y}} &= -\frac{\partial\overline{\Omega}_I}{\partial\log\overline{Y}} = -\overline{\Omega}_N\overline{\Omega}_I\overline{\eta}_I.\end{aligned}$$

For the response of the aggregate cost elasticity, we have

$$\begin{aligned}\frac{d\log\overline{\mathcal{E}}}{d\log W_I} &= \frac{\partial\log\overline{\mathcal{E}}}{\partial\log W_I}\left(1-\frac{d\log W_N}{d\log W_I}\right) + \frac{\partial\log\overline{\mathcal{E}}}{\partial\log\overline{Y}}\cdot\frac{d\log\overline{Y}}{d\log W_I},\\ &= \overline{\Omega}_I\frac{\overline{\Omega}_N}{\overline{\mathcal{E}}}\overline{\eta}_I\left(1-\Omega_M^N\cdot\frac{d\log\overline{P}}{d\log W_I}\right) + \left(\overline{\mathcal{E}}^m-\left(\overline{\mathcal{E}}-1\right)\right)\cdot\frac{d\log\overline{Y}}{d\log W_I}.\end{aligned}$$

The remaining object to compute is the

$$\frac{d\log\left(1-\Omega_M^N\right)}{d\log W_I} = \frac{d\log\left(1-\Omega_M^N\right)}{d\log W_M}\frac{d\log W_P}{d\log W_I} = \Omega_M^N\left(\sigma_M^N-1\right)\frac{d\log W_P}{d\log W_I}.$$

Next, note that the price of materials is the same as the price of the final output $W_M \equiv$

$\overline{P}$. This allows us to compute the price of final output as:

$$\begin{aligned}
\frac{d\log\overline{P}}{d\log W_I} &= \frac{\partial\log\overline{P}}{\partial\log W_I} + \frac{\partial\log\overline{P}}{\partial\log W_N}\frac{d\log W_N}{d\log W_I} + \frac{\partial\log\overline{P}}{\partial\log\overline{Y}}\frac{d\log\overline{Y}}{d\log W_I}, \\
&= \overline{\Omega}_I\left(1+\tfrac{\overline{\Omega}_N}{\overline{\mathcal{E}}}\overline{\eta}_I\right) + \frac{\partial\log\mathcal{C}'}{\partial\log W_N}\,\Omega_M^N\frac{d\log W_M}{d\log W_I} + \overline{\mathcal{E}}^m\frac{d\log\overline{Y}}{d\log W_I}, \\
&= \overline{\Omega}_I\left(1+\tfrac{\overline{\Omega}_N}{\overline{\mathcal{E}}}\overline{\eta}_I\right) + \overline{\Omega}_N\left(1-\tfrac{\overline{\Omega}_I}{\overline{\mathcal{E}}}\overline{\eta}_I\right)\,\Omega_M^N\frac{d\log\overline{P}}{d\log W_I} + \overline{\mathcal{E}}^m\frac{d\log\overline{Y}}{d\log W_I}, \\
&= \frac{\overline{\Omega}_I\left(1+\frac{\overline{\Omega}_N}{\overline{\mathcal{E}}}\overline{\eta}_I\right) + \overline{\mathcal{E}}^m\frac{d\log\overline{Y}}{d\log W_I}}{1-\left(1-\frac{\overline{\Omega}_I}{\overline{\mathcal{E}}}\overline{\eta}_I\right)\overline{\Omega}_M}.
\end{aligned}$$

Combining everything, we now have

$$\begin{aligned}
\frac{d\log\overline{Y}}{d\log W_I} &= -\frac{d\log\overline{P}}{d\log W_I} - \frac{d\log\overline{FS}_O}{d\log W_I}, \\
&= -\frac{d\log\overline{P}}{d\log W_I} \\
&\quad -\overline{\Omega}_I\left(\overline{\sigma}_I-1\right)\left(1-\Omega_M^N\cdot\frac{d\log\overline{P}}{d\log W_I}\right) + \overline{\Omega}_I\overline{\eta}_I\cdot\frac{d\log\overline{Y}}{d\log W_I} \\
&\quad +\overline{\Omega}_I\tfrac{\overline{\Omega}_N}{\overline{\mathcal{E}}}\overline{\eta}_I\left(1-\Omega_M^N\cdot\frac{d\log\overline{P}}{d\log W_I}\right) + \left(\overline{\mathcal{E}}^m-\left(\overline{\mathcal{E}}-1\right)\right)\cdot\frac{d\log\overline{Y}}{d\log W_I} \\
&\quad -\Omega_M^N\left(\sigma_M^N-1\right)\frac{d\log\overline{P}}{d\log W_I}, \\
&= -\left[1+\Omega_M^N\left(\sigma_M^N-1\right)-\overline{\Omega}_I\Omega_M^N\left(\overline{\sigma}_I-\tfrac{\overline{\Omega}_N}{\overline{\mathcal{E}}}\overline{\eta}_I-1\right)\right]\frac{d\log\overline{P}}{d\log W_I} \\
&\quad -\overline{\Omega}_I\left(\overline{\sigma}_I-\tfrac{\overline{\Omega}_N}{\overline{\mathcal{E}}}\overline{\eta}_I-1\right) + \left(\overline{\mathcal{E}}^m-\left(\overline{\mathcal{E}}-1\right)+\overline{\Omega}_I\overline{\eta}_I\right)\cdot\frac{d\log\overline{Y}}{d\log W_I}, \\
&= -\left[1+\Omega_M^N\left(\sigma_M^N-1-\overline{\Omega}_I\left(\overline{\sigma}_I-\tfrac{\overline{\Omega}_N}{\overline{\mathcal{E}}}\overline{\eta}_I-1\right)\right)\right] \\
&\qquad\times\frac{\overline{\Omega}_I\left(1+\frac{\overline{\Omega}_N}{\overline{\mathcal{E}}}\overline{\eta}_I\right)+\overline{\mathcal{E}}^m\frac{d\log\overline{Y}}{d\log W_I}}{1-\left(1-\frac{\overline{\Omega}_I}{\overline{\mathcal{E}}}\overline{\eta}_I\right)\overline{\Omega}_M} \\
&\quad -\overline{\Omega}_I\left(\overline{\sigma}_I-\tfrac{\overline{\Omega}_N}{\overline{\mathcal{E}}}\overline{\eta}_I-1\right) + \left(\overline{\mathcal{E}}^m-\left(\overline{\mathcal{E}}-1\right)+\overline{\Omega}_I\overline{\eta}_I\right)\cdot\frac{d\log\overline{Y}}{d\log W_I}, \\
&= -\left(1+\Omega_M^N\cdot\Xi\right)\left(\overline{\Omega}_I\left(1+\tfrac{\overline{\Omega}_N}{\overline{\mathcal{E}}}\overline{\eta}_I\right)+\overline{\mathcal{E}}^m\frac{d\log\overline{Y}}{d\log W_I}\right) \\
&\quad -\overline{\Omega}_I\left(\overline{\sigma}_I-\tfrac{\overline{\Omega}_N}{\overline{\mathcal{E}}}\overline{\eta}_I-1\right) + \left(\overline{\mathcal{E}}^m-\left(\overline{\mathcal{E}}-1\right)+\overline{\Omega}_I\overline{\eta}_I\right)\cdot\frac{d\log\overline{Y}}{d\log W_I},
\end{aligned}$$

where in the last equality, we have defined

$$\overline{\Xi} \equiv \frac{1}{\Omega_M^N}\left(\frac{1+\Omega_M^N\left(\sigma_M^N-1-\overline{\Omega}_I\left(\overline{\sigma}_I-\frac{\overline{\Omega}_N}{\overline{\mathcal{E}}}\overline{\eta}_I-1\right)\right)}{1-\left(1-\frac{\overline{\Omega}_I}{\overline{\mathcal{E}}}\overline{\eta}_I\right)\overline{\Omega}_M}-1\right),$$

$$=\frac{\left(1-\frac{\overline{\Omega}_I}{\overline{\mathcal{E}}}\overline{\eta}_I\right)\overline{\Omega}_N-\overline{\Omega}_I\left(\overline{\sigma}_I-\frac{\overline{\Omega}_N}{\overline{\mathcal{E}}}\overline{\eta}_I-1\right)+\sigma_M^N-1}{1-\left(1-\frac{\overline{\Omega}_I}{\overline{\mathcal{E}}}\overline{\eta}_I\right)\overline{\Omega}_N\Omega_M^N},$$

$$=\frac{\overline{\Omega}_N-\overline{\Omega}_I\left(\overline{\sigma}_I-1\right)+\sigma_M^N-1}{1-\left(1-\frac{\overline{\Omega}_I}{\overline{\mathcal{E}}}\overline{\eta}_I\right)\overline{\Omega}_M}.$$

We can now find the following expression for the response in the aggregate output:

$$\frac{d\log\overline{Y}}{d\log W_I}=-\frac{\overline{\Omega}_I\overline{\sigma}_I+\Omega_M^N\cdot\overline{\Xi}\cdot\overline{\Omega}_I\left(1+\frac{\overline{\Omega}_N}{\overline{\mathcal{E}}}\overline{\eta}_I\right)}{\overline{\mathcal{E}}-\overline{\Omega}_I\overline{\eta}_I-\overline{\mathcal{E}}^m\cdot\Omega_M^N\cdot\overline{\Xi}}.$$

For the response of the share of non-IT/non-materials in income, we find

$$\frac{d\log\overline{P}}{d\log W_I}=\frac{1}{1-\left(1-\frac{\overline{\Omega}_I}{\overline{\mathcal{E}}}\overline{\eta}_I\right)\overline{\Omega}_M}\left[\overline{\Omega}_I\left(1+\frac{\overline{\Omega}_N}{\overline{\mathcal{E}}}\overline{\eta}_I\right)-\overline{\mathcal{E}}^m\frac{\overline{\Omega}_I\overline{\sigma}_I+\Omega_M^N\cdot\overline{\Xi}\cdot\overline{\Omega}_I\left(1+\frac{\overline{\Omega}_N}{\overline{\mathcal{E}}}\overline{\eta}_I\right)}{\overline{\mathcal{E}}-\overline{\Omega}_I\overline{\eta}_I-\overline{\mathcal{E}}^m\cdot\Omega_M^N\cdot\overline{\Xi}}\right]$$

And for the response of the share of non-IT/non-materials in income, we find

$$\frac{d\log\overline{FS}_O}{d\log W_I}=-\frac{d\log\overline{Y}}{d\log W_I}-\frac{\overline{\Omega}_I\left(1+\frac{\overline{\Omega}_N}{\overline{\mathcal{E}}}\overline{\eta}_I\right)+\overline{\mathcal{E}}^m\frac{d\log\overline{Y}}{d\log W_I}}{1-\left(1-\frac{\overline{\Omega}_I}{\overline{\mathcal{E}}}\overline{\eta}_I\right)\overline{\Omega}_M},$$

$$=-\frac{1}{1-\left(1-\frac{\overline{\Omega}_I}{\overline{\mathcal{E}}}\overline{\eta}_I\right)\overline{\Omega}_M}\overline{\Omega}_I\left(1+\frac{\overline{\Omega}_N}{\overline{\mathcal{E}}}\overline{\eta}_I\right)$$

$$+\left(1+\frac{1}{1-\left(1-\frac{\overline{\Omega}_I}{\overline{\mathcal{E}}}\overline{\eta}_I\right)\overline{\Omega}_M}\overline{\mathcal{E}}^m\right)\frac{\overline{\Omega}_I\overline{\sigma}_I+\Omega_M^N\cdot\overline{\Xi}\cdot\overline{\Omega}_I\left(1+\frac{\overline{\Omega}_N}{\overline{\mathcal{E}}}\overline{\eta}_I\right)}{\overline{\mathcal{E}}-\overline{\Omega}_I\overline{\eta}_I-\overline{\mathcal{E}}^m\cdot\Omega_M^N\cdot\overline{\Xi}},$$

$$=\frac{1}{1-\left(1-\frac{\overline{\Omega}_I}{\overline{\mathcal{E}}}\overline{\eta}_I\right)\overline{\Omega}_M}\left[\left(1+\overline{\mathcal{E}}^m-\left(1-\frac{\overline{\Omega}_I}{\overline{\mathcal{E}}}\overline{\eta}_I\right)\overline{\Omega}_M\right)\frac{\overline{\Omega}_I\overline{\sigma}_I+\Omega_M^N\cdot\overline{\Xi}\cdot\overline{\Omega}_I\left(1+\frac{\overline{\Omega}_N}{\overline{\mathcal{E}}}\overline{\eta}_I\right)}{\overline{\mathcal{E}}-\overline{\Omega}_I\overline{\eta}_I-\overline{\mathcal{E}}^m\cdot\Omega_M^N\cdot\overline{\Xi}}-1-\frac{\overline{\Omega}_N}{\overline{\mathcal{E}}}\overline{\eta}_I\right].$$

□

Let us start by assuming the value added production function in the main text, whereby the share of materials is zero, $\Omega_M^N\equiv 0$. Equations (OA.4.3) and (OA.4.4) are reduced in this case to Equations (25) and (26) in the main text.

To simplify the expressions in the case with nonzero share of materials, let us consider the specification of gross production functions in Appendix OA.5.1.2 with $\sigma_M^N = 1$. Moreover, let us consider a case where the aggregate elasticity of substitution for IT is close to unity $\overline{\sigma}_I \approx 1$ and the aggregate production is close to scale-invariant, in which case Equations (OA.4.3) and (OA.4.4) simplify to:

$$\frac{d \log \overline{Y}}{d \log W_I} \approx -\frac{\overline{\Omega}_I}{\overline{\mathcal{E}}\left(1 - \overline{\Omega}_M\right) - \overline{\mathcal{E}}^m \, \overline{\Omega}_M}, \tag{OA.4.6}$$

$$\frac{d \log \overline{FS}_O}{d \log W_I} \approx \frac{\overline{\Omega}_I}{1 - \overline{\Omega}_M} \left[\frac{1 - \overline{\Omega}_M + \overline{\mathcal{E}}^m}{\overline{\mathcal{E}}\left(1 - \overline{\Omega}_M\right) - \overline{\mathcal{E}}^m \, \overline{\Omega}_M} - 1\right]. \tag{OA.4.7}$$

Table OA.8: Estimation Results: Alternative Specifications

		Nonhomothetic CES	CES	*S-H* Comp.	IT Labor	Gross Output
Scale-dependence parameter	ϵ	0.433		0.325	0.436	0.252
		(0.026)		(0.018)	(0.018)	(0.008)
Elasticity of substitution	σ	0.280	0.170	0.106	0.303	0.128
		(0.034)	(0.041)	(0.018)	(0.020)	(0.011)
Cost elasticity parameter	γ	0.939	0.975	0.926	0.899	0.971
		(0.004)	(0.004)	(0.004)	(0.006)	(0.002)
Observations	N	307504	307504	307504	222938	306989

Note: Results of the estimation procedure for the pooled sample of all firms using different specifications for firm-level technology. Standard errors are reported in brackets. Columns 2 presents the estimated model parameters for a CES production function (where ϵ is constrained to be 0). Columns 3 presents the estimated model parameters for a production function featuring software/hardware complementarity. Column 4 presents the estimated model parameters for a production function with IT labor. Column 5 presents the estimated model parameters for a gross output production function.

OA.5 Details on the Estimation Strategy and Results

OA.5.1 Estimation Using Alternative Production Function Specifications

OA.5.1.1 CES Production Functions

The first and second columns of Table OA.8 compare our key estimated parameters for the pooled sample of all industries between our nhCES specification (featuring scale-dependece) with the standard scale-invariant CES specification, nested in our specification under the restriction $\epsilon = 0$.[21] Even under CES, we still find that the estimated elasticity of substitution is below unity. The estimated values appear smaller relative to the nhCES specification in both samples of firms, which suggests that ignoring scale-dependence may result in a downward bias in our estimated values of the elasticities of substitution. The estimate for the cost elasticity parameter is slightly larger in the CES case ($\gamma \approx 0.98$). However, in the CES case, this number determines the exogenous degree of returns to scale for all firms, while as we saw, the degree of returns to scale is endogenous under the nhCES specification. As we would expect, the estimated value of the cost elasticity parameter under CES implies a scale elasticity that falls between the two limits implied by the nhCES production function. This constant estimate masks substantial

[21] Table OA.13 also reports the factor elasticities as well as the parameters of the Markov process, and additionally provides a comparison with the Cobb-Douglas specification, also nested in our specification under the restrictions $\epsilon = 0$ and $\sigma = 1$. See Section OA.5 for further details on the algorithm used for the estimation and for the schemes used for the estimation of the Cobb-Douglas and CES production functions.

Table OA.9: Estimation Results: Decomposition of the Cross-Sectional IT Intensity-Size Relationship

Specification	κ_I	$(1-\sigma)\epsilon$	κ_w	κ_ϕ	ϵ	σ
nhCES	0.22	0.31	-0.03	0.10	0.43	0.28
CES	0.22	0	-0.03	-0.29	0	0.17
CES (with nhCES σ)	0.22	0	-0.03	-0.33	0	0.28

Note: Results of the decomposition of the cross-sectional relationship between relative IT demand and firm size based on Equation (OA.5.1) for three specifications: nhCES, CES, and CES using the elasticity of substitution estimated for the nhCES specifications.

heterogeneity in returns to scale across firms that is implied by the nhCES production function.

Revisiting the Facts: nhCES vs. CES Specifications Let us now revisit our motivating fact from Section 2 of the main text in light of the estimated nhCES and CES models. Equation (36) of the main text provides us with a log linear relationship between the relative IT demand, firm output, relative IT prices (which we allow to vary across firms based on prevailing wages $W_{L,it}$ in their corresponding location), and IT-augmenting productivity. Consider cross-sectional regressions of log relative IT demand $x_{I,it} - x_{N,it}$ and log relative price of IT w_{it} on log firm output $y_{i,t}$ including industry-time fixed effects (where variations across firms in the latter case are due to variations in local wages). Let κ_I and κ_w denote the corresponding coefficients on log firm output, respectively. Then, Equation (36) implies the following linear constraint on these coefficients[22]

$$\kappa_I = (1-\sigma)\,\epsilon - \sigma\,\kappa_w - (1-\sigma)\;\kappa_\phi, \tag{OA.5.1}$$

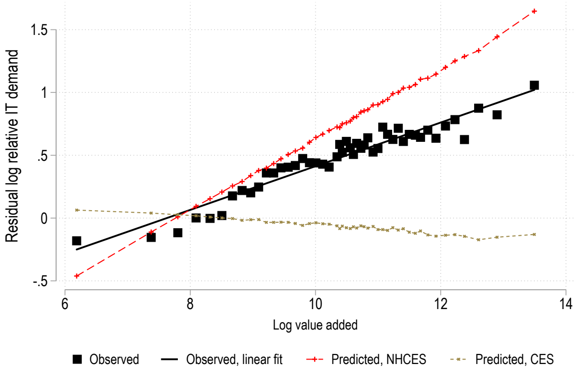
where κ_ϕ denotes the corresponding coefficient when regressing unobserved IT-augmenting productivity ϕ_{it} on log firm output.

Table OA.9 presents the results of this decomposition using the estimated nhCES and CES specifications. In the nhCES case, our estimated scale-dependence explains more than 100% of the cross-sectional relationship to scale-dependence, given by the value of $\kappa_I = 0.22$. The implied relationship between IT-augmenting and firm size is therefore a positive one ($\kappa_\phi = 0.10$). In contrast, the CES case implies that all of the relationship is driven by the relationship between IT-agumenting productivity and firm size. Since the

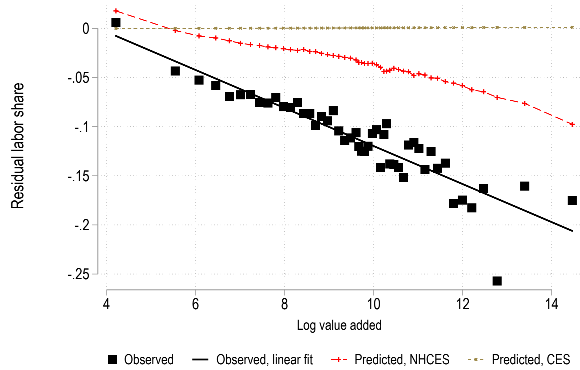
[22] To see why, note that we can write the coefficient of regression as $\kappa_I \equiv \mathbb{E}\left[\mathbb{C}\left(x_I - x_N, y \mid J\right)\right] / \mathbb{E}\left[\mathbb{V}\left(y \mid J\right)\right]$ where we have used J to denote the random variable indicating the value of the fixed effect. The linearity of Equation (36) of the main paper then leads to Equation (OA.5.1).

Figure OA.2: Cross-Sectional Facts: With and Without Scale Dependence

(a) Relative IT Demand and Firm Scale



(b) Labor Share and Firm Scale



Note: Panel (a) presents the binscatter plot of log relative IT demand ($x_{I,it} - x_{N,it}$) and log firm value added (y_{it}), conditional on industry-time fixed effects in the data. The relationship in the data is compared with the predictions of the estimated nhCES and CES demand systems, without accounting for IT-augmenting productivity. Panel (b) presents the binscatter plot of labor share and log firm value added (y_{it}), conditional on industry-time fixed effects in the data. The relationship is compared with the predictions of the estimated nhCES and CES demand systems, without accounting for IT-augmenting productivity.

estimated elasticity of substitution is less than one, this case implies the counterintuitive prediction that firm size is *negatively* associated with IT-biased productivity ($\kappa_\phi = -0.29$). Furthermore, the table shows that this result is not driven by the differences in the elasticities of substitution, but is solely attributable to the lack of scale-dependence under the CES specification.

As an alternative angle on the same fact, Figure OA.2a provides a visual comparison of the cross-sectional relationship between relative IT demand and firm size, on the one hand, and the predicted values based on the two estimated nhCES and CES demand systems without the IT-augmenting productivity, on the other. Here, again, we see that scale-dependence, under the nhCES specification, predicts even a stronger relationship than that observed in the data. The remainder of the predicted relationship is absorbed in the positive cross-sectional relationship between the residual IT-augmenting productivity and firm size. In contrast, scale-invariance, under the CES specification, predicts very little of the cross-sectional relationship in the absence of the residual IT-augmenting productivity, which as we saw has to be negative in order to rationalize the observed relationship.

For completion, Figure OA.2b provides a similar comparison for the implied labor share predicted by both specifications to be given by

$$FS_{L,it} = (1-\alpha)\,\frac{1-\Omega_{I,it}}{\mathcal{E}_{it}}.$$

We show the predicted values without including the residual IT-augmenting productivity. In this case, nhCES specification explains only part of the negative relationship between firm size and labor share. Once again, the CES specification does not capture any of the relationship.

OA.5.1.2 Gross Production Function

Assume a gross production function following the same expression as in Equation (30) in the main text, but in which now Y_{it} stands for gross output and the bundle of non-IT inputs is given by

$$X_{N,it} \equiv K_{it}^{\alpha} M_{it}^{\alpha_M} L_{it}^{1-\alpha-\alpha_M},$$

and where M_{it} stands for material inputs (net of inventory) from the BRN+RSI.[23] The nhCES gross production function in logarithmic terms is still given by Equation (35) in the main text, where we now have $x_{N,it} \equiv \alpha k_{it} + \alpha_M m_{it} + (1-\alpha-\alpha_M)\, l_{it}$ and $x_{I,it} \equiv \beta s_{it} + (1-\beta)\, h_{it}$. We assume that material is a flexible input with a price that is equalized across all firms. Lemma OA.5.1 (presented on page 72 below) gives an extension of Lemma 2 in the main text that allows us to express the software per employee ratio as

$$\begin{aligned} s_{it} - l_{it} = & -\sigma\left(w_{S,t} - w_{L,nt}\right) + (1-\sigma)\,\epsilon\, y_{it} + (1-\sigma)\left[\alpha_K\left(k_{it} - l_{it}\right) + \alpha_M\left(m_{it} - l_{it}\right) - (1-\beta)\left(h_{it} - s_{it}\right)\right] \\ & + (\sigma - 1)\,\phi_{it}. \end{aligned} \tag{OA.5.2}$$

Equation (OA.5.2) allows us to write the IT-biased productivity ϕ_{it} in terms of the observables and model parameters. Henceforth, we can follow an identification strategy similar to the case of our benchmark estimation, the details of which are provided in Section OA.5.10.

Column 5 of Table OA.8 presents the resulting estimates of our key parameters under this specification. The scale-dependence parameter is positive and significant, albeit smaller than the case of the value added specification. The elasticity of substitution parameter remains below unity, becoming even smaller than the value added case. The cost elascticity parameter is fairly close to the benchmark estimate.

OA.5.1.3 IT Aggregator Featuring Software/Hardware Complementarity

In this case, we assume an alternative value added production function, once again given by the expression in Equation (30) in the main text, but in which now the bundle of IT

[23] See Section OA.2.4.4.

inputs is given by the CES aggregator

$$X_{I,it} \equiv \left(\beta^{\frac{1}{\varsigma}} S_{it}^{\frac{\varsigma-1}{\varsigma}} + (1-\beta)^{\frac{1}{\varsigma}} H_{it}^{\frac{\varsigma-1}{\varsigma}} \right)^{\frac{\varsigma}{\varsigma-1}}.$$

In this case, Lemma OA.5.2 (presented on page 74 below) gives an extension of Lemma 2 in the main text that allows us to express the software per employee ratio as

$$\begin{aligned} s_{it} - l_{it} &= -\sigma \left(w_{S,t} - w_{L,nt} \right) + (1-\sigma)\, \epsilon\, y_{it} \\ &\quad + (1-\sigma) \left[\alpha \left(k_{it} - l_{it} \right) - \left(\tfrac{1}{1-\sigma} - \tfrac{1}{1-\varsigma} \right) \log \left(1 + \left(\tfrac{1-\beta}{\beta} \right)^{\frac{1}{\varsigma}} \left(\tfrac{H_{it}}{S_{it}} \right)^{\frac{\varsigma-1}{\varsigma}} \right) \right] + (\sigma - 1)\, \phi_{it}. \end{aligned} \tag{OA.5.3}$$

Just like before, Equation (OA.5.3) allows us to write the IT-biased productivity ϕ_{it} in terms of the observables and model parameters. We follow the same steps as in the baseline specification with the vector of observables $\boldsymbol{d}_{it} \equiv (w_{S,t} - w_{L,nt}, l_{it}, k_{it}, s_{it}, h_{it}, y_{it})$ and $\boldsymbol{y}_{it} \equiv (y_{it}, s_{it})'$, and use the moment conditions given by Equations (41) and (42), where we have the same instruments z_{it}^{y} and z_{it}^{s} as in Equations (43) and (44). We note that we cannot identify the elasticity of substitution ς between software and hardware since we do not have credibly exogenous variation in relative price of hardware to software across firms (or over time) in our data. As such, we choose to estimate the specification above for a predetermined value of the elasticity ς that corresponds to complementarity between software and hardware. More details on the identification strategy are provided in Section OA.5.11

Column 3 of Table OA.8 presents the resulting estimates of our key parameters under this specification, assuming that the elasticity of substitution between hardware and software $\varsigma = 0.5$. The scale-dependence parameter is positive and significant, and fairly close to the benchmark estimate. The elasticity of substitution and the cost elasticity parameters are both close to our benchmark estimates.

OA.5.1.4 Production Function with IT Labor

Here, we assume a value added production function, again given by the expression in Equation (30) in the main text, but in which now the bundle of IT inputs includes the number of technical IT workers T_{it} according to

$$X_{I,it} \equiv S_{it}^{\beta} T_{it}^{\beta_T} H_{it}^{1-\beta-\beta_T}.$$

Lemma OA.5.3 (presented in on page 75 below) gives an extension of Lemma 2 in the main text that allows us to express the software per employee ratio as

$$s_{it} - l_{it} = -\sigma\left(w_{S,t} - w_{L,nt}\right) + (1-\sigma)\,\epsilon\, y_{it} + (1-\sigma)\left[\alpha\left(k_{it} - l_{it}\right) - (1-\beta)\left(h_{it} - s_{it}\right) - \beta_T\left(\tau_{it} - l_{it}\right)\right] + (\sigma - 1)\,\phi_{it}, \tag{OA.5.4}$$

where $\tau_{it} \equiv \log T_{it}$ stands for the logarithm of the number of technical IT workers. Equation (OA.5.4) allows us to write the IT-biased productivity ϕ_{it} in terms of the observables and model parameters. Once again, we follow an identification strategy similar to the case of our benchmark estimation, the details of which are provided in Section OA.5.12.

We follow a broad definition of technical workers, similar to the one used by Harrigan et al. (2018) in the matched employer-employee dataset for French firms and workers (DADS). We define IT workers as those workers in technical management, engineers, and technicians.[24] Column 4 of Table OA.8 presents the resulting estimates of our key parameters under this specification. The scale-dependence parameter is positive and significant, and even stronger than under our benchmark specification. The elasticity of substitution parameter is close to our benchmark estimate, and the cost elascticity parameter is also below unity, while slightly smaller than the benchmark estimate.

OA.5.2 Illustration of the Structural Identification

In this section, we illustrate how different moments help identify the key model parameters, i.e., the scale-dependence parameter ϵ and the elasticity of substitution σ, in the structural estimation laid out above. Recall from Equation (38) in the main text that the log stock of software satisfies $s_{it} = f_s\left(\boldsymbol{d}_{it}; \varsigma\right) + (\sigma - 1)\,\phi_{it}$, where ς is the tuple of all production function parameters and function f_s is given by:

$$f_s\left(\boldsymbol{d}_{it}; \varsigma\right) \equiv l_{it} - \sigma\left(w_{S,t} - w_{L,nt}\right) + (1-\sigma)\,\epsilon\, y_{it} + (1-\sigma)\left[\alpha\left(k_{it} - l_{it}\right) - (1-\beta)\left(h_{it} - s_{it}\right)\right]. \tag{OA.5.5}$$

Importantly, $w_{S,t} - w_{L,nt}$ is the log price of software relative to wages in location n that hosts firm i.

OA.5.2.1 Identification of the Elasticity of Substitution

First, let us examine the identification of the elasticity of substitution σ, by focusing on the relationship between the software per worker and the relative price of software in the expression $s_{it} = f_s\left(\boldsymbol{d}_{it}; \varsigma\right) + \widetilde{\phi}_{it}$. From Equation (OA.5.5), we can define a function

[24] See Section OA.2.4.4 of the Online Appendix.

$f_s^\sigma(\boldsymbol{d}_{it}; \varsigma)$ that controls for all the terms in $f_s(\boldsymbol{d}_{it}; \varsigma)$ *other than the relative price of software* as:

$$f_s^\sigma(\boldsymbol{d}_{it}; \varsigma) \equiv (1-\sigma)\,\epsilon\, y_{it} + (1-\sigma)\left[\alpha\,(k_{it} - l_{it}) - (1-\beta)\,(h_{it} - s_{it})\right].$$

This allows us to write software per worker as:

$$\begin{aligned} s_{it} - l_{it} &= -\sigma\,(w_{S,t} - w_{L,nt}) + f_s^\sigma(\boldsymbol{d}_{it}; \varsigma) + \widetilde{\phi}_{it}, \\ &= -\sigma\,(w_{S,t} - w_{L,nt}) + \underbrace{f_s^\sigma(\boldsymbol{d}_{it}; \varsigma) + \widetilde{\mu}_{\phi,t}\left(\boldsymbol{y}_{it-1} - \boldsymbol{f}(\boldsymbol{d}_{it-1}; \varsigma); \boldsymbol{\rho}, \varsigma\right)}_{\equiv Controls^\sigma(\boldsymbol{d}_{it}, \boldsymbol{d}_{it-1}; \boldsymbol{\rho}, \varsigma)} + \widetilde{u}_{\phi,it}, \end{aligned} \tag{OA.5.6}$$

where we have substituted for the contemporaneous IT-biased productivity $\widetilde{\phi}_{it}$ by its expectation conditional on the lagged productivity and the additional productivity innovation from Equation (40) in the main text.

To demonstrate the identification of σ in Equation (OA.5.6), we consider the sample of firms used in the estimation results reported in Table OA.13 in the pooled sample of all industries. We can now use Equation (OA.5.6) to examine the identification of the elasticity of substitution σ using the Bartik-style shift-share instrument z_{nt}. One of our moment conditions imposes the orthogonality of the shift-share instrument z_{nt} on the innovation to IT-biased productivity $\widetilde{u}_{\phi,it}$ in Equation (OA.5.6). According to this moment condition, the shift-share variable z_{nt} acts as an instrument for the price of software relative to wages in Equation (OA.5.6).

Figure OA.12 and Table OA.10 provide an illustration for how the shift-share instrument helps identify the elasticity of substitution σ. First, Figure OA.12b shows the scatter plot of the LHS of Equation (OA.5.6), minus the controls $Controls^\sigma(\boldsymbol{d}_{it}, \boldsymbol{d}_{it-1}; \widehat{\boldsymbol{\rho}}, \widehat{\varsigma})$, *averaged by location* as a function of the log relative price of software across locations. The controls are evaluated at the estimated model parameters $(\widehat{\boldsymbol{\rho}}, \widehat{\varsigma})$ shown in Table 2 of the main text. The top-right corner of Table OA.10 below shows that the resulting coefficient is around -0.30. All other things equal, locations where the local price of software is higher have on average lower software intensity of labor.

Let us now consider a two stage least square (2SLS) estimation of the LHS of Equation (OA.5.6) (minus the controls) on log relative price of software, using the shift-share variable z_{nt} as an instrument. Figure OA.12d shows the first stage: a scatter plot of the log price of software relative to local wages as a function of the shift-share instrument. Locations where larger shares of initial employment is in sectors that grow nationally have higher local wages and lower relative price of software. Figure OA.12f shows the reduced-form scatter plot: average log software per worker as a function of the shift-share

Table OA.10: Identification of Scale-Dependence (ϵ) and Elasticity of Substitution (σ)

	Scale-dependence	Elasticity of substitution
OLS Estimation	0.2774	-0.3017
	(0.0008)	(0.0066)
Observations	307,504	4,135
R2	0.2937	0.3329
First Stage	0.9822	-0.0384
	(0.0005)	(0.0125)
Observations	307,504	4,135
R2	0.9200	0.0023
First stage *F*-stat		9.372
Reduced Form	0.3045	0.0218
	(0.0008)	(0.0066)
Observations	307,504	4,135
R2	0.3376	0.0027
Second Stage	0.3101	-0.5672
	(0.0008)	(0.1707)
Observations	307,504	4,135
R2	0.3376	0.0027

Note: This table reports the relationships in the data between software stock per worker (minus the controls), and the logarithms of value added and relative price of software, and their respective instruments, the logarithm of lagged value added and the shift-share instrument for local labor demand. Standard errors are reported in brackets. In the first and in the second columns, OLS corresponds to a simple regression of software stock per worker (minus the controls) on RHS (corresponding to Equations OA.5.7 and OA.5.6, respectively), first stage to a regression of RHS on its instrument, reduced form to a regression of software stock per worker (minus the controls) on the instrument, and second stage to a regression of software stock per worker (minus the controls) on the predicted value of RHS from the first stage. First-stage F-stat for lagged instrument is very large. For the identification of σ, firms' outcomes are averaged at the local $\times$ year level, regressions are weighted by the number of firms at each location $\times$ year. First-stage The sample of firms corresponds to the estimation results reported in Table 2 (All industries).

instrument across locations. As expected, locations that witness higher labor demand are those where firms substitute away from labor toward software. Finally, Figure OA.12h shows the scatter plot of the average log software intensity of labor (minus the controls) as a function of the *predicted* price of software relative to local wages, based on the shift-share instrument. As the bottom-right corner of Table OA.10 shows, the resulting elasticity is now around -0.57.[25]

OA.5.2.2 Identification of the Scale-Dependence Parameter

Next, we examine the identification of the scale-dependence parameter ϵ, by focusing on the relationship between the software intensity of labor and the log output in the expression $s_{it} = f_s\left(\boldsymbol{d}_{it};\varsigma\right) + \widetilde{\phi}_{it}$. From Equation (OA.5.5), we can define a function $f_s^{\epsilon}\left(\boldsymbol{d}_{it};\varsigma\right)$ that

[25]Note that this is only one among the several moment conditions used for the estimation results presented Table 2 of the main paper, a fact that helps explain the difference between the elasticity of substitution reported in that table and the one in Table OA.10 here.

controls for all the terms in $f_s(\boldsymbol{d}_{it};\varsigma)$ *other than the firm output* as:

$$f_s^{\epsilon}(\boldsymbol{d}_{it};\varsigma) \equiv -\sigma\left(w_{S,t}-w_{L,nt}\right)+(1-\sigma)\left[\alpha\left(k_{it}-l_{it}\right)-(1-\beta)\left(h_{it}-s_{it}\right)\right].$$

This allows us to write the software intensity of labor as:

$$\begin{aligned} s_{it}-l_{it} &= (1-\sigma)\,\epsilon\, y_{it}+f_s^{\epsilon}(\boldsymbol{d}_{it};\varsigma)+\widetilde{\phi}_{it}, \\ &= (1-\sigma)\,\epsilon\, y_{it}+\underbrace{f_s^{\epsilon}(\boldsymbol{d}_{it};\varsigma)+\widetilde{\mu}_{\phi,t}(\boldsymbol{d}_{it-1};\boldsymbol{\rho},\varsigma)}_{\equiv Controls^{\epsilon}(\boldsymbol{d}_{it},\boldsymbol{d}_{it-1};\boldsymbol{\rho},\varsigma)}+\widetilde{u}_{\phi,it}. \end{aligned} \tag{OA.5.7}$$

Once again, we consider the sample of firms corresponding to the estimation results reported in Table 2 of the main text. We can now use Equation (OA.5.7) to examine the identification of the scale-dependence parameter ϵ using the lagged instruments. In particular, we focus on lagged log output y_{it-1}. One of our moment conditions imposes the orthogonality of log lagged output on the innovation to IT-biased productivity $\widetilde{u}_{\phi,it}$ in Equation (OA.5.7). According to this moment condition, log lagged output y_{it-1} acts as an instrument for log output y_{it} in Equation (OA.5.7).

Figure OA.12a shows the scatter plot of the LHS of (OA.5.7), minus the controls as a function of $\boldsymbol{d}_{it}$ and $\boldsymbol{d}_{it-1}$, on the y-axis and the log output y_{it} on the x-axis. The top-left corner of Table OA.10 shows that the resulting coefficient is around 0.28.

Let us now consider a two stage least square estimation of the LHS of Equation (OA.5.7) (minus the controls) on log output, using lagged output y_{it-1} as an instrument. Figure OA.12c shows the first stage: a scatter plot current log output as a function of lagged output. The figure shows a strong persistence in log output. Figure OA.12e shows the reduced-form scatter plot: log software per worker as a function of lagged output. Finally, Figure OA.12g shows the scatter plot of the log software intensity of labor (minus the controls) as a function of the *predicted* current log output, based on lagged output as an instrument. Note that the control term $Controls^{\epsilon}(\boldsymbol{d}_{it},\boldsymbol{d}_{it-1};\widehat{\boldsymbol{\rho}},\widehat{\varsigma})$ accounts for the potential correlation between lagged output and the current IT-biased productivity. As the bottom-left corner of Table OA.10 shows, the resulting elasticity is now around 0.31.

OA.5.2.3 Comparison with the Export IV

Section 2 of the main text introduces firm-level export-demand shocks, an alternative instrument for size y_{it} that could be used for the identification the scale-dependence parameter ϵin Equation (OA.5.7) above. This instrument is limited to the sample of exporting

Table OA.11: Identification of Scale-dependence (ϵ) and Elasticity of Substitution (σ), Exporting Firms

	Scale-dependence		Elasticity of substitution
	Lagged Valued Added IV	Export Demand IV	
OLS Estimation	0.2832	0.2832	-0.2752
	(0.0013)	(0.0013)	(0.0087)
Observations	99,421	99,421	3,717
R2	0.3141	0.3141	0.2134
First Stage	0.9819	0.0343	-0.0423
	(0.0007)	(0.0007)	(0.0127)
Observations	99,421	99,421	3,717
R2	0.9453	0.0210	0.0030
First stage F-stat		2133.907	11.134
Reduced Form	0.2946	0.0110	0.0184
	(0.0013)	(0.0004)	(0.0076)
Observations	99,421	99,421	3,717
R2	0.3334	0.0085	0.0016
Second Stage	0.3001	0.3210	-0.4344
	(0.0013)	(0.0110)	(0.1787)
Observations	99,421	99,421	3,717
R2	0.3334	0.0085	0.0016

Note: This table reports the relationships in the data between software stock per worker (minus the controls), and the logarithms of value added and relative price of software, and their respective instruments, the logarithm of lagged value added and the shift-share instrument for local labor demand. Standard errors are reported in brackets. In the first and in the second columns, OLS corresponds to a simple regression of software stock per worker (minus the controls) on RHS (corresponding to Equations OA.5.7 and OA.5.6, respectively), first stage to a regression of RHS on its instrument, reduced form to a regression of software stock per worker (minus the controls) on the instrument, and second stage to a regression of software stock per worker (minus the controls) on the predicted value of RHS from the first stage. First-stage F-stat for lagged instrument is very large, and due to differences in specification and choice of clustering, F-stat for export instrument reported here differs from Table 1 in the main text. For the identification of σ, firms' outcomes are averaged at the local $\times$ year level, regressions are weighted by the number of firms at each location $\times$ year. The sample, exporting firms, is narrower than in the estimation results reported in Table 2 in the main text.

firms. Figure OA.13 and Table OA.11 provide an illustration for how the shift-share instrument helps identify the elasticity of substitution σ in the sample of exporting firms, and how the export instrument helps identify the scale-dependence parameter ϵ. The second stage estimates of σ and ϵ are similar to those presented in the previous section on the larger sample and using lagged output. On the sample of exporting firms, second stage estimates of ϵ are also very close whether one uses the lagged instrument or the export instrument; with elasticities of around 0.3 in both cases.

OA.5.3 Setting Up the GMM Estimation

Let $\boldsymbol{d}$ stand for the observed data and $\boldsymbol{\rho} \equiv (\rho_\theta, \rho_\phi)$ for the vector of persistence coefficients. From Equations (41) and (42) in the main text, we can write the $2M$-dimensional (for $M = 8$) vector of moments $\boldsymbol{g}\left(\boldsymbol{d}_{it};\varsigma,\boldsymbol{\rho}\right)$ as

$$g_m\left(\boldsymbol{d}_{it};\varsigma,\boldsymbol{\rho}\right) \equiv z_{mi,t-1}\left(\Theta_{it}\left(\varsigma\right) - \rho_{\theta\theta}\Theta_{it-1}\left(\varsigma\right) - \rho_{\theta\phi}\Phi_{it-1}\left(\varsigma\right)\right),\ m \leq M,$$
$$g_m\left(\boldsymbol{d}_{it};\varsigma,\boldsymbol{\rho}\right) \equiv z_{mi,t-1}\left(\Phi_{it}\left(\varsigma\right) - \rho_{\phi\theta}\Theta_{it-1}\left(\varsigma\right) - \rho_{\phi\phi}\Phi_{it-1}\left(\varsigma\right)\right),\ m \geq M+1,$$

where $z_{mi,t-1} \in \mathcal{Z}_{i,t-1}$ is each of the instruments and function Φ defines IT biased productivity as a function of observed data and model parameters

$$\Phi\left(\boldsymbol{d}_{it};\varsigma\right) = \frac{1}{\sigma-1}\left(\sigma\widehat{w}_{it} + s_{it} - l_{it}\right) + \epsilon\, y_{it} + \alpha\left(k_{it} - l_{it}\right) - \left(1-\beta\right)\left(h_{it} - s_{it}\right), \quad \text{(OA.5.8)}$$

while function Θ is the corresponding function for factor symmetric productivity:

$$\Theta\left(\boldsymbol{d}_{it};\varsigma\right) \equiv \gamma y_{it} + \frac{\sigma}{1-\sigma}\log\left[e^{\frac{\sigma-1}{\sigma}\left(\alpha k_{it} + (1-\alpha) l_{it}\right)} + e^{\frac{\sigma-1}{\sigma}\left(\beta s_{it} + (1-\beta) h_{it} - \epsilon y_{it} + \Phi\left(\widehat{w}_{it}, l_{it}, k_{it}, s_{it}, h_{it}, y_{it};\varsigma\right)\right)}\right], \quad \text{(OA.5.9)}$$

where $\widehat{w}_{it} \equiv \left(w_{S,t} - w_{L,nt}\right)$ for $i \in \mathcal{J}_n$ is the relative price of software faced by firm i at time t. User cost of software $w_{S,t}$ has no unit (euros per euros of software capital). Wage $w_{Li,t}$ is in thousand euros per worker, l_{it} is number of workers, and y_{it}, k_{it}, s_{it}, h_{it} are in thousand euros.

The GMM estimator is then given by

$$\left(\widehat{\varsigma},\widehat{\boldsymbol{\rho}}\right) \equiv \underset{(\varsigma,\boldsymbol{\rho})}{\operatorname{argmax}}\left[\sum_{it}\boldsymbol{g}\left(\boldsymbol{d}_{it};\varsigma,\boldsymbol{\rho}\right)\right]' \widehat{\boldsymbol{\Xi}}\left[\sum_{it}\boldsymbol{g}\left(\boldsymbol{d}_{it};\varsigma,\boldsymbol{\rho}\right)\right],$$

where $\widehat{\boldsymbol{\Xi}}$ is a $J \times J$ full-rank matrix. Alternatively, we can write

$$\boldsymbol{g}_{it}\left(\varsigma,\boldsymbol{\rho}\right) \equiv \mathbf{Z}_{it}'\boldsymbol{e}_{it}\left(\varsigma,\boldsymbol{\rho}\right),$$

where we have defined $\boldsymbol{z}_{it-1} \equiv \left(z_{1,it-1},\cdots,z_{M,it-1}\right)'$ and

$$\boldsymbol{Z}_{it} \equiv \begin{pmatrix} \boldsymbol{z}_{i,t-1} & \boldsymbol{0} \\ \boldsymbol{0} & \boldsymbol{z}_{i,t-1} \end{pmatrix}, \qquad \boldsymbol{e}_{it} \equiv \begin{pmatrix} \Theta_{it}\left(\varsigma\right) - \rho_{\theta\theta}\Theta_{it-1}\left(\varsigma\right) - \rho_{\theta\phi}\Phi_{it-1}\left(\varsigma\right) \\ \Phi_{it}\left(\varsigma\right) - \rho_{\phi\theta}\Theta_{it-1}\left(\varsigma\right) - \rho_{\phi\phi}\Phi_{it-1}\left(\varsigma\right) \end{pmatrix}.$$

We use a nonlinear system 2SLS estimator $\left(\widehat{\varsigma}^0,\widehat{\boldsymbol{\rho}}^0\right)$, setting

$$\widehat{\boldsymbol{\Xi}} \equiv \left(\frac{1}{NT}\sum_{it}\boldsymbol{Z}_{it}'\boldsymbol{Z}_{it}\right)^{-1}.$$

OA.5.4 Initializing Parameter Estimates

To find reasonable initial parameters for the optimization step in the GMM estimation, we use a cascading series of intuitive simplifications of the model to lead the optimizer to the relevant parts of the parameter space. A key step in this approach is a log-linear approximation of the production function that helps create a bridge between the GMM moment conditions derived from our model with those typically used under the assumption of a Cobb-Douglas production function. More specifically, this approximation gives us a log-linear expression for the factor-symmetric productivity function $\theta_{it} = \widetilde{\Theta}(\boldsymbol{d}_{it}; \varsigma)$ that we use in lieu of Equation (OA.5.11). We will present this approximation in Section OA.5.5 below, and discuss how we use it to initialize the search for model parameters in Section OA.5.6.

OA.5.5 Log-Linear Cobb-Douglas Approximation for the Factor-Symmetric Productivity Function

Recall the evolution of productivities in Equation (39) of the main text and consider a firm i in industry s with a stationary distribution of productivities G_s. The Markov process of productivity states in this industry for each firm converges to a long-run distribution of productivities with industry-level mean values $(\theta_s \equiv \mathbb{E}_{G_s}[\theta], \phi_s \equiv \mathbb{E}_{G_s}[\phi])$. Similarly, let inputs (K_s, L_s, H_s, S_s) be the corresponding mean values of inputs for a firm with the corresponding mean productivity states. Log-linearizing the production function around the average industry level gives us

$$\begin{aligned}(\gamma + \Omega_{I,s}\epsilon)(y_{it} - y_s) \approx\ & \Omega_{I,s}\left[\beta(s_{it} - s_s) + (1-\beta)(h_{it} - h_s) + (\phi_{it} - \phi_s)\right] \\ & + (1 - \Omega_{I,s})\left[\alpha(k_{it} - k_s) + (1-\alpha)(l_{it} - l_s)\right] + \theta_{it} - \theta_s,\end{aligned} \tag{OA.5.10}$$

where we have defined $\Omega_{I,s} \equiv \left(e^{\phi_s + \theta_s} X_{I,j} / Y_s^{\gamma+\epsilon}\right)^{1-1/\sigma}$ and, as before, used small cap letter to denote the logarithms of the corresponding variables.

We can rewrite the expression above in a form that resembles the Cobb-Douglas production function:

$$y_{it} \approx \gamma_1 k_{it} + \gamma_2 l_{it} + \gamma_3 s_{it} + \gamma_4 h_{it} + \widetilde{\theta}_{it},$$

where we have defined:

$$\gamma_1 \equiv \frac{\alpha(1 - \Omega_{I,s})}{\gamma + \Omega_{I,s}\epsilon},$$

$$\gamma_2 \equiv \frac{(1-\alpha)(1-\Omega_{I,s})}{\gamma + \Omega_{I,s}\epsilon},$$
$$\gamma_3 \equiv \frac{\beta\Omega_{I,s}}{\gamma + \Omega_{I,s}\epsilon},$$
$$\gamma_4 \equiv \frac{(1-\beta)\Omega_{I,s}}{\gamma + \Omega_{I,s}\epsilon},$$
$$\widetilde{\theta}_{it} \equiv (\gamma_1+\gamma_2+\gamma_3+\gamma_4)\,\theta_{it} + (\gamma_3+\gamma_4)\,\phi_{it} + \widetilde{\theta}_s,$$
$$\widetilde{\theta}_s \equiv -\left((\gamma_1+\gamma_2+\gamma_3+\gamma_4)\,\theta_s + (\gamma_3+\gamma_4)\,\phi_s\right) + \left[y_s - (\gamma_1 k_s + \gamma_2 l_s + \gamma_3 s_s + \gamma_4 h_s)\right].$$

Let us also define a scaling of the IT-biased productivity and rewrite the cost minimization condition as:

$$\begin{aligned}\widetilde{\phi}_{it} &\equiv (\sigma-1)\,\phi_{it}, \\ &= s_{it} - l_{it} + \sigma\widehat{w}_t + (\sigma-1)\left[\epsilon\, y_{it} + \alpha\,(k_{it}-l_{it}) - (1-\beta)\,(h_{it}-s_{it})\right].\end{aligned}$$

Now, we substitute Equations (OA.5.8) and (OA.5.9) with:

$$\widetilde{\Theta}\left(\boldsymbol{d}_{it};\boldsymbol{\gamma}\right) \equiv y_{it} - (\gamma_1 k_{it} + \gamma_2 l_{it} + \gamma_3 s_{it} + \gamma_4 h_{it}), \tag{OA.5.11}$$
$$\widetilde{\Phi}\left(\boldsymbol{d}_{it};\sigma,\epsilon,\boldsymbol{\gamma}\right) \equiv s_{it} - l_{it} + \sigma\widehat{w}_{it} + (\sigma-1)\left[\epsilon\, y_{it} + \frac{\gamma_1}{\gamma_1+\gamma_2}\,(k_{it}-l_{it}) - \frac{\gamma_4}{\gamma_3+\gamma_4}\,(h_{it}-s_{it})\right]. \tag{OA.5.12}$$

Next, note that we can write:

$$\begin{aligned}\begin{pmatrix}\widetilde{\theta}_{it}\\ \widetilde{\phi}_{it}\end{pmatrix} &= \boldsymbol{B}\begin{pmatrix}\theta_{it}\\ \phi_{it}\end{pmatrix} + \begin{pmatrix}\widetilde{\theta}_s\\ 0\end{pmatrix}, \\ &= \boldsymbol{B}\times\left[\begin{pmatrix}\rho_{\theta\theta} & \rho_{\theta\phi}\\ \rho_{\phi\theta} & \rho_{\phi\phi}\end{pmatrix}\begin{pmatrix}\theta_{it-1}\\ \phi_{it-1}\end{pmatrix} + \begin{pmatrix}\eta_\theta+\mu_\theta t\\ \eta_\phi+\mu_\phi t\end{pmatrix} + \begin{pmatrix}u_{\theta,it}\\ u_{\phi,it}\end{pmatrix}\right] + \begin{pmatrix}\widetilde{\theta}_s\\ 0\end{pmatrix}, \\ &= \boldsymbol{B}\times\left[\begin{pmatrix}\rho_{\theta\theta} & \rho_{\theta\phi}\\ \rho_{\phi\theta} & \rho_{\phi\phi}\end{pmatrix}\boldsymbol{B}^{-1}\begin{pmatrix}\widetilde{\theta}_{it-1}\\ \widetilde{\phi}_{it-1}\end{pmatrix} + \begin{pmatrix}\eta_\theta+\mu_\theta t\\ \eta_\phi+\mu_\phi t\end{pmatrix} + \begin{pmatrix}u_{\theta,it}\\ u_{\phi,it}\end{pmatrix}\right] + \begin{pmatrix}\widetilde{\theta}_s\\ 0\end{pmatrix}, \\ &= \begin{pmatrix}\rho_{\widetilde{\theta}\widetilde{\theta}} & \rho_{\widetilde{\theta}\widetilde{\phi}}\\ \rho_{\widetilde{\phi}\widetilde{\theta}} & \rho_{\widetilde{\phi}\widetilde{\phi}}\end{pmatrix}\begin{pmatrix}\widetilde{\theta}_{it-1}\\ \widetilde{\phi}_{it-1}\end{pmatrix} + \begin{pmatrix}\eta_{\widetilde{\theta}}+\mu_{\widetilde{\theta}} t\\ \eta_{\widetilde{\phi}}+\mu_{\widetilde{\phi}} t\end{pmatrix} + \begin{pmatrix}u_{\widetilde{\theta},it}\\ u_{\widetilde{\phi},it}\end{pmatrix},\end{aligned}$$

where we have defined the matrix

$$\boldsymbol{B} \equiv \begin{pmatrix}\gamma_1+\gamma_2+\gamma_3+\gamma_4 & \gamma_3+\gamma_4\\ 0 & \sigma-1\end{pmatrix},$$

and we have

$$\begin{pmatrix} \rho_{\widetilde{\theta}\widetilde{\theta}} & \rho_{\widetilde{\theta}\widetilde{\phi}} \\ \rho_{\widetilde{\phi}\widetilde{\theta}} & \rho_{\widetilde{\phi}\widetilde{\phi}} \end{pmatrix} \equiv \boldsymbol{B} \begin{pmatrix} \rho_{\theta\theta} & \rho_{\theta\phi} \\ \rho_{\phi\theta} & \rho_{\phi\phi} \end{pmatrix} \boldsymbol{B}^{-1},$$

$$\begin{pmatrix} \eta_{\widetilde{\theta}} + \mu_{\widetilde{\theta}} t \\ \eta_{\widetilde{\phi}} + \mu_{\widetilde{\phi}} t \end{pmatrix} \equiv \boldsymbol{B} \begin{pmatrix} \eta_{\theta} + \mu_{\theta} t \\ \eta_{\phi} + \mu_{\phi} t \end{pmatrix} + \begin{pmatrix} \widetilde{\theta}_s \\ 0 \end{pmatrix},$$

$$\begin{pmatrix} u_{\widetilde{\theta},it} \\ u_{\widetilde{\phi},it} \end{pmatrix} \equiv \boldsymbol{B} \begin{pmatrix} u_{\theta,it} \\ u_{\phi,it} \end{pmatrix}.$$

OA.5.6 Algorithm for Solving the Problem

Our initialization procedure is as follows. We first start with an approximation that considers the log-linearization above, assumes no persistence in the dynamics of the productivity processes $\boldsymbol{\mu}_t = 0$, and ignores the heterogeneity of software relative price $\widehat{w}_{it}$. We then separately estimate the following two simplified versions of Equations (OA.5.11) and (OA.5.12) with linear 2SLS:

$$y_{it} = \gamma_1^0 k_{it} + \gamma_2^0 l_{it} + \gamma_3^0 s_{it} + \gamma_4^0 h_{it} + v_{\theta,it}^0, \tag{OA.5.13}$$

$$s_{it} - l_{it} = \gamma_5^0 y_{it} + \gamma_6^0 (k_{it} - l_{it}) + \gamma_7^0 (s_{it} - h_{it}) + v_{\phi,it}^0. \tag{OA.5.14}$$

We estimate Equation (OA.5.13), instrumenting s_{it}, l_{it}, h_{it} and k_{it} by their lagged values, and Equation (OA.5.14), instrumenting y_{it}, $k_{it} - l_{it}$, and $h_{it} - s_{it}$ by their lagged values. This allows us to retrieve initial, predicted values of the initial residuals $\widetilde{\theta}_{it}^0 = v_{\theta,it}^0$ and $\widetilde{\phi}_{it}^0 = v_{\phi,it}^0$, where the superscript denotes the step (currently the initial one) in the recursive procedure. We then use an OLS estimation of the persistence, trends, and shifters from the joint productivity process according to the simple regression:

$$\begin{pmatrix} \widetilde{\theta}_{it}^0 \\ \widetilde{\phi}_{it}^0 \end{pmatrix} = \begin{pmatrix} \rho_{\widetilde{\theta}\widetilde{\theta}}^0 & \rho_{\widetilde{\theta}\widetilde{\phi}}^0 \\ \rho_{\widetilde{\phi}\widetilde{\theta}}^0 & \rho_{\widetilde{\phi}\widetilde{\phi}}^0 \end{pmatrix} \begin{pmatrix} \widetilde{\theta}_{it-1}^0 \\ \widetilde{\phi}_{it-1}^0 \end{pmatrix} + \begin{pmatrix} \eta_{\widetilde{\theta}}^0 + \mu_{\widetilde{\theta}}^0 t \\ \eta_{\widetilde{\phi}}^0 + \mu_{\widetilde{\phi}}^0 t \end{pmatrix} + \begin{pmatrix} u_{\widetilde{\theta},it}^0 \\ u_{\widetilde{\phi},it}^0 \end{pmatrix},$$

following Equation (39) in the main text.

We then iterate the following steps. Armed with estimates from step $\tau - 1$, we ρ-differentiate Equations (OA.5.13) and (OA.5.14) :

$$\Delta\left(y_{it}; \rho_{\widetilde{\theta}\widetilde{\theta}}^{\tau-1}\right) - \rho_{\widetilde{\theta}\widetilde{\phi}}^{\tau-1} \cdot \widetilde{\phi}_{it-1}^{\tau-1} = \Delta\left(\gamma_1^\tau k_{it} + \gamma_2^\tau l_{it} + \gamma_3^\tau s_{it} + \gamma_4^\tau h_{it} + v_{\theta,it}^\tau; \rho_{\widetilde{\theta}\widetilde{\theta}}^{\tau-1}\right), \tag{OA.5.15}$$

$$\Delta\left(s_{it}-l_{it};\rho^{\tau-1}_{\widetilde{\phi}\widetilde{\phi}}\right)-\Delta_{\rho^{\tau-1}_{\phi\phi}}b^{\tau}_{it}-\rho^{\tau-1}_{\widetilde{\phi}\widetilde{\theta}}\cdot\widetilde{\theta}^{\tau-1}_{it-1}=\Delta\left(\gamma^{\tau}_{5}\,y_{it}+\gamma^{\tau}_{8}\left(\widehat{w}_{it}+b^{\tau}_{it}\right)+v^{\tau}_{\phi,it};\rho^{\tau-1}_{\widetilde{\phi}\widetilde{\phi}}\right), \tag{OA.5.16}$$

where we have defined ρ-differenced variables as $\Delta(x_{it};\rho)=x_{it}-\rho x_{it}$, and let $b^{\tau}_{it}=\frac{\gamma^{\tau}_{1}}{\gamma^{\tau}_{1}+\gamma^{\tau}_{2}}(k_{it}-l_{it})+\frac{\gamma^{\tau}_{4}}{\gamma^{\tau}_{3}+\gamma^{\tau}_{4}}(s_{it}-h_{it})$. We estimate separately Equation (OA.5.15) then Equation (OA.5.16) with linear 2SLS. As in the initial step, we retrieve the predicted values of the initial residuals $\widetilde{\theta}^{\tau}_{it}=v^{\tau}_{\theta,it}$ and $\widetilde{\phi}^{\tau}_{it}=v^{\tau}_{\phi,it}$ and estimate by OLS the persistence, trends and shifters from the joint productivity process:

$$\begin{pmatrix}\widetilde{\theta}^{\tau}_{it}\\ \widetilde{\phi}^{\tau}_{it}\end{pmatrix}=\begin{pmatrix}\rho^{\tau}_{\widetilde{\theta}\widetilde{\theta}} & \rho^{\tau}_{\widetilde{\theta}\widetilde{\phi}}\\ \rho^{\tau}_{\widetilde{\phi}\widetilde{\theta}} & \rho^{\tau}_{\widetilde{\phi}\widetilde{\phi}}\end{pmatrix}\begin{pmatrix}\widetilde{\theta}^{\tau}_{it-1}\\ \widetilde{\phi}^{\tau}_{it-1}\end{pmatrix}+\begin{pmatrix}\eta^{\tau}_{\widetilde{\theta}}+\mu^{\tau}_{\widetilde{\theta}}t\\ \eta^{\tau}_{\widetilde{\phi}}+\mu^{\tau}_{\widetilde{\phi}}t\end{pmatrix}+\begin{pmatrix}u^{\tau}_{\theta,it}\\ u^{\tau}_{\phi,it}\end{pmatrix}.$$

We stop the iterative procedure when the maximum of the absolute differences of all parameters of the productivity process between steps $\tau-1$ and τ is below 0.01 or the number of iterations reaches 20. In practice, this procedure converges in fewer than three steps. In the final step τ_f, we compute the following parameter values:

$$\begin{aligned}\epsilon^{\tau_f} &= \frac{\gamma_5^{\tau_f}}{1+\gamma_8^{\tau_f}},\\ \sigma^{\tau_f} &= -\gamma_8^{\tau_f}.\end{aligned}$$

In the third stage of the initialization procedure, we simultaneously estimate Equations (OA.5.11) and (OA.5.12) by two-step GMM using $\gamma_1^{\tau_f}$, $\gamma_2^{\tau_f}$, $\gamma_3^{\tau_f}$, $\gamma_4^{\tau_f}$, ϵ^{τ_f}, σ^{τ_f}, $\rho^{\tau_f}_{\widetilde{\theta}\widetilde{\theta}}$, $\rho^{\tau_f}_{\widetilde{\theta}\widetilde{\phi}}$, $\rho^{\tau_f}_{\widetilde{\phi}\widetilde{\theta}}$, $\rho^{\tau_f}_{\widetilde{\phi}\widetilde{\phi}}$, $\eta^{\tau_f}_{\widetilde{\theta}}$, $\mu^{\tau_f}_{\widetilde{\theta}}$, $\eta^{\tau_f}_{\widetilde{\phi}}$, and $\mu^{\tau_f}_{\widetilde{\phi}}$ as initial guesses. In the fourth stage, we simultaneously estimate Equations (OA.5.9) and (OA.5.8) by two-step GMM, using the results from the third stage as an initial guess. In this last stage, we constrain σ, α and β to take positive values by re-parameterizing the problem in terms of $\widetilde{\sigma}$, $\widetilde{\alpha}$ and $\widetilde{\beta}$, and replacing the actual parameters in Equations (OA.5.9) and (OA.5.8) by $\sigma=e^{\widetilde{\sigma}}$, $\alpha=\widetilde{\alpha}^2$ and $\beta=\widetilde{\beta}^2$.[26]

OA.5.7 Connection to Reduced-Form Identification

We should highlight an important concern with the reduced-form IV estimates reported in Table 1 in the main text and Table OA.7 in this online appendix, in light of our results in Section 4.2 of the main paper. Let us compare our specification in Equation (OA.3.1) in Section OA.3 above, with Equation (37) in the main text, which accounts for the potential

[26]In both these stages, we use s_{it-1}, l_{it-1}, h_{it-1}, k_{it-1}, $\widetilde{\theta}_{it-1}$ and $\widetilde{\phi}_{it-1}$ as instruments for the first equation, and y_{it-1}, $k_{it-1}-l_{it-1}$, $h_{it-1}-s_{it-1}$, $\widetilde{\theta}_{it-1}$, $\widetilde{\phi}_{it-1}$ and the local wage instrument z_{it} as instruments for the second equation.

Table OA.12: Correlations Between Non-Flexible Relative to Flexible Inputs and the Instrument for Size.

	Non IT Capital Stock per Worker	Hardware to Software Stock Ratio
Shift-Share Instrument	-0.0204	-0.1104
	(0.0054)	(0.0242)
Observations	121,886	121,886

Note: The dependent variable is the log capital to labor ratio in column (1), and the log hardware to software ratio in column (2). Standard errors are reported in brackets. The independent variable is the instrument used in the IV regressions, here product demand shocks. The time period is 1995-2007. All columns include a full set of 3-digit industry classification fixed effects interacted with year fixed effects.

presence of adjustment costs in the firm's choices of hardware and non-IT capital:

$$s_{it} - l_{it} = -\sigma\left(w_{S,t} - w_{L,nt}\right) + (1-\sigma)\,\epsilon\, y_{it} + (1-\sigma)\left[\alpha\left(k_{it} - l_{it}\right) - (1-\beta)\left(h_{it} - s_{it}\right)\right] + (\sigma - 1)\,\phi_{it}.$$

We notice that Equation (OA.3.1) abstracts away from the potential within-firm variations in capital-to-labor ratio $k_{it} - l_{it}$ and hardware-to-software ratio $h_{it} - s_{it}$ on the right hand side. If our instruments ds_{it}^{P} is correlated with these variations, and if those are in turn correlated with variations in output y_{it}, then our identification strategy the coefficients reported in may feature a potential bias. Table OA.12 below reports the regression coefficients of the within-firm variations in capital-to-labor ratio $k_{it} - l_{it}$ and hardware-to-software ratio $h_{it} - s_{it}$ on our instrument, which show sizable and significant coefficients. This is one of the reasons that we prefer to rely on our structural estimation strategy in Section 4.2, rather than the results reported here, for the calibration of our model.

OA.5.8 Complete Set of Estimated Parameters

Table 2 in the main text provides the production parameters estimated from this last stage. The last two sets of rows of the Table OA.13 below present the parameters of the Markov process. We find fairly sizable autocorrelations $\left(\rho_{\theta\theta}, \rho_{\phi\phi}\right)$ in the dynamics of the two productivity states implying a high degree of persistence. However, we find very small, but precisely estimated, cross terms in the persistence coefficients $\left(\rho_{\theta\phi}, \rho_{\phi\phi}\right)$ and trends $\left(\mu_{\theta}, \mu_{\phi}\right)$ in the evolution of the productivity states. The patterns of the parameters of the Markov process appear fairly robust under both samples and across all specifications.

OA.5.9 Solution Across A38 Industries

The A38 level includes 38 industries, which is more detailed than the 1-digit NAF level (10 industries) but more aggregated than the 2-digits NAF level (88 industries). Excluding

Table OA.13: Estimation Results

		All Industries			Manufacturing		
		nhCES	CES	CD	nhCES	CES	CD
Scale-dependence paramater	ϵ	0.433			0.466		
		(0.026)			(0.027)		
Elasticity of substitution	σ	0.280	0.170		0.131	0.041	
		(0.034)	(0.041)		(0.036)	(0.061)	
Cost elasticity parameter	γ	0.939	0.975	0.985	0.946	1.004	1.012
		(0.004)	(0.004)	(0.004)	(0.006)	(0.006)	(0.008)
Capital elasticity of non-IT	α	0.062	0.058	0.061	0.146	0.146	0.165
		(0.003)	(0.003)	(0.005)	(0.007)	(0.007)	(0.011)
Software elasticity of IT	β	0.042	0.127	-0.176	0.152	0.239	0.171
		(0.034)	(0.032)	(0.050)	(0.034)	(0.036)	(0.063)
Persistence of θ	$\rho_{\theta\theta}$	0.839	0.832	0.821	0.842	0.826	0.831
		(0.003)	(0.003)	(0.002)	(0.004)	(0.004)	(0.004)
Persistence of θ wrt ϕ	$\rho_{\theta\phi}$	-0.008	-0.010		-0.008	-0.013	
		(0.001)	(0.001)		(0.001)	(0.001)	
Persistence of ϕ wrt θ	$\rho_{\phi\theta}$	-0.058	-0.037		-0.049	-0.032	
		(0.004)	(0.003)		(0.004)	(0.004)	
Persistence of ϕ	$\rho_{\phi\phi}$	0.899	0.909		0.900	0.920	
		(0.001)	(0.001)		(0.002)	(0.002)	
Trend for θ	μ_θ	0.002	0.002	-0.004	0.003	0.003	0.001
		(0.000)	(0.000)		(0.000)	(0.000)	
Trend for ϕ	μ_ϕ	0.008	0.008		-0.008	-0.004	
		(0.001)	(0.001)		(0.001)	(0.001)	
Shifter for θ	η_θ	0.556	0.602	0.667	0.474	0.575	0.560
		(0.013)	(0.013)		(0.016)	(0.017)	
Shifter for ϕ	η_ϕ	0.701	0.171		0.715	0.190	
		(0.056)	(0.030)		(0.046)	(0.034)	
Observations	N	307504	307504	312981	148979	148979	150773

Note: Results of the estimation procedure for the pooled sample of all firms in (columns 1-3), and for the pooled sample of manufacturing firms (columns 4-6). Standard errors are reported in brackets. Columns 2 and 5 present the estimated model parameters for a CES production function (where ϵ is constrained to be 0). Columns 3 and 6 present the estimated model parameters for a Cobb-Douglas production function (where σ is additionally constrained to be 1).

agriculture, finance, real estate and nonmarket industries, our sample is comprised of 27 industries. Because some of those industries contain fewer than 50 observations in a given year, we construct three pooled industries (ICT, Research and Energy, mining and utilities), for a new total of 22 industries. These industries span most of the French market economy excluding real estate, finance and agriculture.

Figure OA.3 provides the estimated parameters ϵ, σ and γ across these industries at the A38 level of the aggregated NAF classification.[27] First, note that the estimated

[27] In a few cases where the main procedure with the parameter constraints imposed according to $\sigma = e^{\tilde{\sigma}}$,

Table OA.14: Estimation Results: Alternative Specifications

		All Industries		
		S-H Comp.	IT Labor	Gross Output
Scale-dependence parameter	ϵ	0.325	0.436	0.252
		(0.018)	(0.018)	(0.008)
Elasticity of substitution	σ	0.106	0.303	0.128
		(0.018)	(0.020)	(0.011)
Cost elasticity parameter	γ	0.926	0.899	0.971
		(0.004)	(0.006)	(0.002)
Capital elasticity of non-IT	α	0.072	0.016	0.001
		(0.004)	(0.007)	(0.003)
Materials elasticity of non-IT	α_M			0.627
				(0.008)
Software elasticity of IT	β	0.043	0.000	0.276
		(0.018)	(0.033)	(0.017)
IT Labor elasticity of IT	β_T		0.434	
			(0.036)	
Persistence of θ	$\rho_{\theta\theta}$	0.851	0.863	0.886
		(0.003)	(0.003)	(0.002)
Persistence of θ wrt ϕ	$\rho_{\theta\phi}$	-0.007	-0.013	-0.002
		(0.000)	(0.001)	(0.000)
Persistence of ϕ wrt θ	$\rho_{\phi\theta}$	-0.057	-0.012	-0.041
		(0.003)	(0.004)	(0.005)
Persistence of ϕ	$\rho_{\phi\phi}$	0.887	0.914	0.903
		(0.004)	(0.001)	(0.001)
Trend for θ	μ_θ	0.002	0.003	-0.001
		(0.000)	(0.000)	(0.000)
Trend for ϕ	μ_ϕ	0.004	0.014	0.011
		(0.002)	(0.001)	(0.001)
Shifter for θ	η_θ	0.473	0.527	0.251
		(0.014)	(0.015)	(0.005)
Shifter for ϕ	η_ϕ	0.524	0.499	0.596
		(0.020)	(0.028)	(0.017)
Observations	N	307504	222938	306989

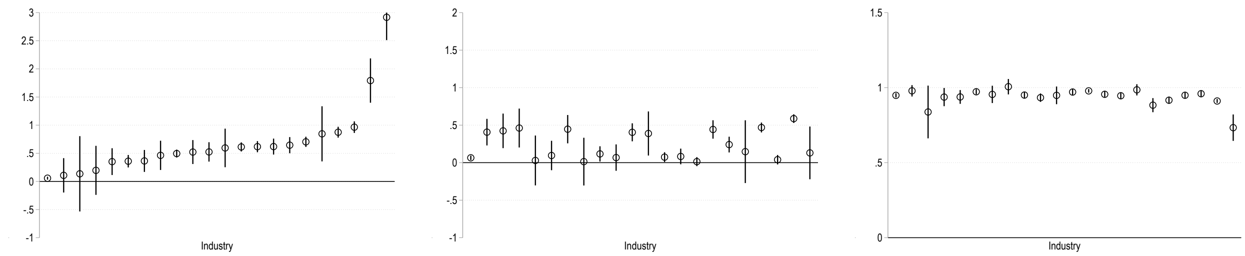
Note: Results of the estimation procedure for the pooled sample of all firms. Standard errors are reported in brackets. Columns 1 presents the estimated model parameters for a production function featuring software/hardware complementarity. Column 2 presents the estimated model parameters for a production function with IT labor. Column 3 presents the estimated model parameters for a gross output production function.

values of the parameter ϵ are positive and significant for most of the industries. The mean and the median estimate across the industries are 0.62 and 0.52, respectively. Second,

and $\beta = \widetilde{\beta}^2$ fails to converge, we subsequently apply modified approaches to imposing the constraints on σ and β in the last stage of our estimation procedure. For three industries ("Computers and electronics", "Transportation", and "Accommodation and food services"), the estimation converged with $\sigma = \widetilde{\sigma}^2$, and for four industries ("Pharmaceuticals", "Rubber and plastic products", "Publishing and motion pictures", and "Research"), the estimation converged with no constraint on β.

Figure OA.3: Industry-Level Estimates

(a) Scale-Dependence Parameter ϵ (b) Substitution Elasticity σ (c) Cost Elasticity Parameter γ



Note: This figure presents the estimated values of the parameters ϵ, σ and γ across 22 industries of the market economy (level A38 of the NAF classification) in France. The bands around the estimates show the 90% confidence intervals. Industries are sorted from lowest to largest ϵ.

estimated values of the parameter σ are never above 1. The mean and the median estimate across the industries are 0.22 and 0.13, respectively. The estimated values of the cost elasticity parameter γ are generally close to 1 across industries (the mean and medians across industries are 0.94 and 0.95, respectively). Table OA.30 provides the full set of nonlinear results, and Table OA.31 display linear results for all industries.

OA.5.10 Details on the Gross Output Production Function Specification

Consider the gross output production specification presented in Section OA.5.1.2. The following lemma generalizes Lemma 2 in the main text to this case.

Lemma OA.5.1. *Under Assumption 1′ in the main text, and under general forms of adjustment costs for non-IT capital and hardware, the firm's choices of inputs in each period satisfy*

$$s_{it} - l_{it} = -\sigma\left(w_{S,t} - w_{L,nt}\right) + (1-\sigma)\,\epsilon\, y_{it} + (1-\sigma)\left[\alpha\left(k_{it} - l_{it}\right) + \alpha_M\left(m_{it} - l_{it}\right) - (1-\beta)\left(h_{it} - s_{it}\right)\right] + (\sigma - 1)\,\phi_{it}, \tag{OA.5.17}$$

where $w_{S,t} - w_{L,nt}$ is the (location-specific) logarithm of the price of software relative to wages.

Proof. The proof closely follows the same steps as those of the proof for Lemma 2 in the main draft, provided in Section OA.1 above. Since we assume that material is a flexible input, the value function of the firm satisfies :

$$\begin{aligned} V_t\left(\theta_{it}, \phi_{it}, \boldsymbol{\tau}_{it}, K_{it-1}, H_{it-1}, S_{it-1}\right) = \max_{Y_{it}, L_{it}, K_{it}, S_{it}, H_{it}} \; & \mathcal{P}\left(Y_{it}\right) Y_{it} - W_{L,nt} L_{it} - W_{M,t} M_{it} - Q_{S,t}\left(S_{it} - S_{it-1}\left(1-\delta_S\right)\right) \\ & - \mathcal{C}_t^K\left(K_{it}; K_{it-1}, \boldsymbol{\tau}_{it}\right) - \mathcal{C}_t^H\left(H_{it}; H_{it-1}, \boldsymbol{\tau}_{it}\right) \\ & + \frac{1}{1+r_t} \mathbb{E}_{\theta_{it+1}, \phi_{it+1}, \boldsymbol{\tau}_{it+1}}\left[V_{t+1}\left(\theta_{it+1}, \phi_{it+1}, \boldsymbol{\tau}_{it+1}, K_{it}, H_{it}, S_{it}\right) | \mathcal{I}_{it}\right], \end{aligned}$$

$$\text{subject to} \qquad Y_{it} = nhCES\left(e^{\theta_{it}}K_{it}^{\alpha}M_{it}^{\alpha_M}L_{it}^{1-\alpha-\alpha_M}, e^{\phi_{it}+\theta_{it}}S_{it}^{\beta}H_{it}^{1-\beta}\right),$$

with the same notation as that in Equation (OA.1.3). Following the same line of logic, we reach the following first-order conditions for the flexible inputs:

$$W_{L,nt} = \Lambda_{it}\frac{\partial Y_{it}}{\partial X_{N,it}}\frac{\partial X_{N,it}}{\partial L_{it}} = \Lambda_{it}\frac{Y_{it}}{X_{N,it}}\frac{1}{\mathcal{E}_{it}}\left(\frac{e^{\theta_{it}}X_{N,it}}{Y_{it}^{\gamma}}\right)^{1-\frac{1}{\sigma}}(1-\alpha-\alpha_M)\frac{X_{N,it}}{L_{it}}, \quad \text{(OA.5.18)}$$

$$W_{S,t} = \Lambda_{it}\frac{\partial Y_{it}}{\partial X_{I,it}}\frac{\partial X_{I,it}}{\partial S_{it}} = \Lambda_{it}\frac{Y_{it}}{X_{I,it}}\frac{1}{\mathcal{E}_{it}}\left(\frac{e^{\theta_{it}+\phi_{it}}X_{I,it}}{Y_{it}^{\gamma+\epsilon}}\right)^{1-\frac{1}{\sigma}}\beta\frac{X_{I,it}}{S_{it}}, \quad \text{(OA.5.19)}$$

which we can again combine to find the following

$$\begin{aligned}\frac{W_{S,t}}{W_{L,nt}} &= \frac{\beta}{1-\alpha-\alpha_M}\frac{L_{it}}{S_{it}}\left(e^{\phi_{it}}\frac{X_{I,it}}{X_{N,it}}Y_{it}^{-\epsilon}\right)^{1-\frac{1}{\sigma}}, \\ &= \frac{\beta}{1-\alpha-\alpha_M}\left(\frac{S_{it}}{L_{it}}\right)^{-\frac{1}{\sigma}}\left(e^{\phi_{it}}\frac{(H_{it}/S_{it})^{1-\beta}}{(K_{it}/L_{it})^{\alpha}(M_{it}/L_{it})^{\alpha_M}}Y_{it}^{-\epsilon}\right)^{1-\frac{1}{\sigma}},\end{aligned}$$

leading to the desired result. □

Equation (OA.5.17) allows us to write the IT-biased productivity ϕ_{it} in terms of the observables and model parameters. Substituting this expression for ϕ_{it} in Equation (35) then allows us to recover log output y_{it} in terms of observables, model parameters, and factor symmetric productivity θ_{it}. Let $\boldsymbol{d}_{it} \equiv (w_{S,t} - w_{L,nt}, l_{it}, k_{it}, m_{it}, s_{it}, h_{it}, y_{it})$ denote the vector of all relevant data observations for firm $i \in \mathcal{J}_{nt}$ in location n at time t. Letting $\boldsymbol{y}_{it} \equiv (y_{it}, s_{it})'$, Equation (OA.5.17), along with Equation (35) in the main text, together define a vector function $\boldsymbol{f}(\boldsymbol{d}_{it};\varsigma) \equiv (f_y(\boldsymbol{d}_{it};\varsigma), f_s(\boldsymbol{d}_{it};\varsigma))'$ with a corresponding vector of scaled productivity states $\tilde{\boldsymbol{\vartheta}}_{it} \equiv (\theta_{it}/\gamma, (\sigma-1)\phi_{it})'$, which again satisfies Equation (38) in the main text. Thus, we can again apply the same identification strategy as before to estimate Equation (38) in the main text. As before, we let $\tilde{\mu}_{\theta,t}$ and $\tilde{\mu}_{\phi,t}$ stand for the components of the conditional expectation of the scaled productivity $\tilde{\boldsymbol{\mu}}_t \equiv (\tilde{\mu}_{\theta,t}, \tilde{\mu}_{\phi,t})'$. We again use the moment conditions given by Equations (41) and (42) in the main text, where we have the following instruments z_{it}^{y} and z_{it}^{s}:

$$\begin{aligned}&z_{it}^{y} \in \left\{l_{it-1}, k_{it-1}, m_{it-1}, s_{it-1}, h_{it-1}, y_{it-1} - f_y(\boldsymbol{d}_{it-1};\varsigma), s_{it-1} - f_s(\boldsymbol{d}_{it-1};\varsigma), 1, t\right\}, \\ &z_{it}^{s} \in \left\{z_{nt}, k_{it-1} - l_{it-1}, m_{it-1} - l_{it-1}, s_{it-1} - h_{it-1}, y_{it-1} - f_y(\boldsymbol{d}_{it-1};\varsigma), s_{it-1} - f_s(\boldsymbol{d}_{it-1};\varsigma), 1, t\right\},\end{aligned}$$

where z_{nt} is the shift-share instrument for local wages in location n hosting firm i. We use this system of moment conditions to estimate the production function in a nonlinear GMM framework, following a similar strategy for initializing the nonlinear parameter search algorithm as in the case of the value added production function.

OA.5.11 Details on the Specification with Software/Hardware Complementarity

Consider the production specification presented in Section OA.5.1.3, featuring complementarity between software and hardware. The following lemma generalizes Lemma 2 in the main text to this case.

Lemma OA.5.2. *Under Assumption 1′ in the main text, and under general forms of adjustment costs for non-IT capital and hardware, the firm's choices of inputs in each period satisfy*

$$s_{it} - l_{it} = -\sigma\left(w_{S,t} - w_{L,nt}\right) + (1-\sigma)\,\epsilon\, y_{it} \tag{OA.5.20}$$

$$+ (1-\sigma)\left[\alpha\left(k_{it} - l_{it}\right) - \left(\tfrac{1}{\varsigma-1} - \tfrac{1}{\sigma-1}\right)\log\left(1 + \left(\tfrac{1-\beta}{\beta}\right)^{\frac{1}{\varsigma}}\left(\tfrac{H_{it}}{S_{it}}\right)^{\frac{\varsigma-1}{\varsigma}}\right)\right] + (\sigma-1)\,\phi_{it}, \tag{OA.5.21}$$

where $w_{S,t} - w_{L,nt}$ is the (location-specific) logarithm of the price of software relative to wages.

Proof. The proof closely follows the same steps as those of the proof for Lemma 2 in the main draft, provided in Section OA.1 above. The value function of the firm satisfies :

$$\begin{aligned}
V_t\left(\theta_{it}, \phi_{it}, \boldsymbol{\tau}_{it}, K_{it-1}, H_{it-1}, S_{it-1}\right) = \max_{Y_{it}, L_{it}, K_{it}, S_{it}, H_{it}} \; & \mathcal{P}\left(Y_{it}\right) Y_{it} - W_{L,nt} L_{it} - W_{M,t} M_{it} - Q_{S,t}\left(S_{it} - S_{it-1}\left(1-\delta_S\right)\right) \\
& - \mathcal{C}_t^K\left(K_{it}; K_{it-1}, \boldsymbol{\tau}_{it}\right) - \mathcal{C}_t^H\left(H_{it}; H_{it-1}, \boldsymbol{\tau}_{it}\right) \\
& + \frac{1}{1+r_t}\mathbb{E}_{\theta_{it+1}, \phi_{it+1}, \boldsymbol{\tau}_{it+1}}\left[V_{t+1}\left(\theta_{it+1}, \phi_{it+1}, \boldsymbol{\tau}_{it+1}, K_{it}, H_{it}, S_{it}\right) | \mathcal{I}_{it}\right], \\
\text{subject to} \quad Y_{it} &= nhCES\left(e^{\theta_{it}} K_{it}^{\alpha} L_{it}^{1-\alpha}, e^{\phi_{it}+\theta_{it}} X_{I,it}\right), \\
X_{I,it} &= \left(\beta^{\frac{1}{\varsigma}}\, S_{it}^{\frac{\varsigma-1}{\varsigma}} + (1-\beta)^{\frac{1}{\varsigma}}\, S_{it}^{\frac{\varsigma-1}{\varsigma}}\right)^{\frac{\varsigma}{\varsigma-1}},
\end{aligned}$$

where $\varsigma \in (0,1)$, otherwise with the same notation as that in Equation (OA.1.3). Following the same line of logic, we reach the following first-order conditions for the flexible inputs:

$$W_{L,nt} = \Lambda_{it}\frac{\partial Y_{it}}{\partial X_{N,it}}\frac{\partial X_{N,it}}{\partial L_{it}} = \Lambda_{it}\frac{Y_{it}}{X_{N,it}}\frac{1}{\mathcal{E}_{it}}\left(\frac{e^{\theta_{it}} X_{N,it}}{Y_{it}^{\gamma}}\right)^{1-\frac{1}{\sigma}}(1-\alpha)\frac{X_{N,it}}{L_{it}}, \tag{OA.5.22}$$

$$W_{S,t}=\Lambda_{it}\frac{\partial Y_{it}}{\partial X_{I,it}}\frac{\partial X_{I,it}}{\partial S_{it}}=\Lambda_{it}\frac{Y_{it}}{X_{I,it}}\frac{1}{\mathcal{E}_{it}}\left(\frac{e^{\theta_{it}+\phi_{it}}X_{I,it}}{Y_{it}^{\gamma+\epsilon}}\right)^{1-\frac{1}{\sigma}}\beta\left(\frac{X_{I,it}}{S_{it}}\right)^{\frac{1}{\varsigma}}, \tag{OA.5.23}$$

which we can again combine to find the following

$$\begin{aligned}\frac{W_{S,t}}{W_{L,nt}}&=\frac{\beta}{1-\alpha}\frac{L_{it}}{S_{it}}\left(\frac{X_{I,it}}{S_{it}}\right)^{\frac{1}{\varsigma}-1}\left(e^{\phi_{it}}\frac{X_{I,it}}{X_{N,it}}Y_{it}^{-\epsilon}\right)^{1-\frac{1}{\sigma}},\\&=\frac{\beta}{1-\alpha}\left(\frac{S_{it}}{L_{it}}\right)^{-\frac{1}{\sigma}}\left(\frac{X_{I,it}}{S_{it}}\right)^{-\frac{\varsigma-1}{\varsigma}}\left(e^{\phi_{it}}\frac{X_{I,it}/S_{it}}{(K_{it}/L_{it})^{\alpha}}Y_{it}^{-\epsilon}\right)^{1-\frac{1}{\sigma}},\\&=\frac{\beta}{1-\alpha}\left(\frac{S_{it}}{L_{it}}\right)^{-\frac{1}{\sigma}}\left(e^{\phi_{it}}\frac{(X_{I,it}/S_{it})^{\frac{\sigma-\varsigma}{\varsigma(\sigma-1)}}}{(K_{it}/L_{it})^{\alpha}}Y_{it}^{-\epsilon}\right)^{1-\frac{1}{\sigma}},\end{aligned}$$

where we have:

$$\left(\frac{X_{I,it}}{S_{it}}\right)^{\frac{\varsigma-1}{\varsigma}}=1+\left(\frac{1-\beta}{\beta}\right)^{\frac{1}{\varsigma}}\left(\frac{H_{it}}{S_{it}}\right)^{\frac{\varsigma-1}{\varsigma}}.$$

Rewriting the above expression in log terms and reorganizing terms leads to the desired result. □

OA.5.12 Details on the Production Function Specification with IT Labor

Consider production specification presented in Section OA.5.1.4 featuring technical IT workers. The following lemma generalizes Lemma 2 in the main text to this case.

Lemma OA.5.3. *Under Assumption 1′ in the main text, and under general forms of adjustment costs for non-IT capital and hardware, the firm's choices of inputs in each period satisfy*

$$s_{it}-l_{it}=-\sigma\left(w_{S,t}-w_{L,nt}\right)+(1-\sigma)\,\epsilon\,y_{it}+(1-\sigma)\left[\alpha\left(k_{it}-l_{it}\right)-(1-\beta)\left(h_{it}-s_{it}\right)-\beta_T\left(\tau_{it}-l_{it}\right)\right]+(\sigma-1)\,\phi_{it}, \tag{OA.5.24}$$

where $\tau_{it}\equiv\log T_{it}$ *stands for the logarithm of the number of technical IT workers and where* $w_{S,t}-w_{L,nt}$ *is the (location-specific) logarithm of the price of software relative to wages.*

Proof. The proof closely follows the same steps as those of the proof for Lemma 2 in the main draft, provided in Section OA.1 above. The value function of the firm satisfies :

$$\begin{aligned}V_t\left(\theta_{it},\phi_{it},\boldsymbol{\tau}_{it},K_{it-1},H_{it-1},S_{it-1}\right)=\max_{Y_{it},L_{it},K_{it},S_{it},H_{it}}\ &\mathcal{P}\left(Y_{it}\right)Y_{it}-W_{L,nt}L_{it}-W_{M,t}M_{it}-Q_{S,t}\left(S_{it}-S_{it-1}\left(1-\delta_S\right)\right)\\&-\mathcal{C}_t^K\left(K_{it};K_{it-1},\boldsymbol{\tau}_{it}\right)-\mathcal{C}_t^H\left(H_{it};H_{it-1},\boldsymbol{\tau}_{it}\right)\end{aligned}$$

$$+\frac{1}{1+r_t}\mathbb{E}_{\theta_{it+1},\phi_{it+1},\boldsymbol{\tau}_{it+1}}\left[V_{t+1}\left(\theta_{it+1},\phi_{it+1},\boldsymbol{\tau}_{it+1},K_{it},H_{it},S_{it}\right)|\mathcal{I}_{it}\right],$$

$$\text{subject to}\qquad Y_{it}=nhCES\left(e^{\theta_{it}}K_{it}^{\alpha}M_{it}^{\alpha_M}L_{it}^{1-\alpha-\alpha_M},e^{\phi_{it}+\theta_{it}}S_{it}^{\beta}H_{it}^{1-\beta}\right),$$

with the same notation as that in Equation (OA.1.3). Following the same line of logic, we reach the following first-order conditions for the flexible inputs:

$$W_{L,nt}=\Lambda_{it}\frac{\partial Y_{it}}{\partial X_{N,it}}\frac{\partial X_{N,it}}{\partial L_{it}}=\Lambda_{it}\frac{Y_{it}}{X_{N,it}}\frac{1}{\mathcal{E}_{it}}\left(\frac{e^{\theta_{it}}X_{N,it}}{Y_{it}^{\gamma}}\right)^{1-\frac{1}{\sigma}}(1-\alpha)\frac{X_{N,it}}{L_{it}},\tag{OA.5.25}$$

$$W_{S,t}=\Lambda_{it}\frac{\partial Y_{it}}{\partial X_{I,it}}\frac{\partial X_{I,it}}{\partial S_{it}}=\Lambda_{it}\frac{Y_{it}}{X_{I,it}}\frac{1}{\mathcal{E}_{it}}\left(\frac{e^{\theta_{it}+\phi_{it}}X_{I,it}}{Y_{it}^{\gamma+\epsilon}}\right)^{1-\frac{1}{\sigma}}\beta\frac{X_{I,it}}{S_{it}},\tag{OA.5.26}$$

which we can again combine to find the following

$$\begin{aligned}\frac{W_{S,t}}{W_{L,nt}}&=\frac{\beta}{1-\alpha}\frac{L_{it}}{S_{it}}\left(e^{\phi_{it}}\frac{X_{I,it}}{X_{N,it}}Y_{it}^{-\epsilon}\right)^{1-\frac{1}{\sigma}},\\&=\frac{\beta}{1-\alpha}\left(\frac{S_{it}}{L_{it}}\right)^{-\frac{1}{\sigma}}\left(e^{\phi_{it}}\frac{(H_{it}/S_{it})^{1-\beta}(T_{it}/S_{it})^{\beta_T}}{(K_{it}/L_{it})^{\alpha}}Y_{it}^{-\epsilon}\right)^{1-\frac{1}{\sigma}},\end{aligned}$$

leading to the desired result. □

Equation (OA.5.24) allows us to write the IT-biased productivity ϕ_{it} in terms of the observables and model parameters. We follow the same steps as before for the choices of the vector of decisions $\boldsymbol{d}_{it}\equiv(w_{S,t}-w_{L,nt},l_{it},k_{it},s_{it},h_{it},\tau_{it},y_{it})$ for firm $i\in\mathcal{J}_{nt}$ in location n at time t and define the vector of outcomes $\boldsymbol{y}_{it}\equiv(y_{it},s_{it})'$. Again, the moment conditions are given by Equations (41) and (42), where we have the following instruments z_{it}^{y} and z_{it}^{s}:

$$z_{it}^{y}\in\left\{l_{it-1},k_{it-1},s_{it-1},h_{it-1},\tau_{it-1},y_{it-1}-f_y\left(\boldsymbol{d}_{it-1};\varsigma\right),s_{it-1}-f_s\left(\boldsymbol{d}_{it-1};\varsigma\right),1,t\right\},$$
$$z_{it}^{s}\in\left\{z_{nt},k_{it-1}-l_{it-1},s_{it-1}-h_{it-1},\tau_{it-1}-s_{it-1},y_{it-1}-f_y\left(\boldsymbol{d}_{it-1};\varsigma\right),s_{it-1}-f_s\left(\boldsymbol{d}_{it-1};\varsigma\right),1,t\right\},$$

where, as before, z_{nt} is the shift-share instrument for local wages in location n hosting firm i.

OA.6 Details on the Empirical Application to French Macro Trends

OA.6.1 The Decompositions of the Labor Share

In this section, we will present the details of the decompositions of labor share presented in Section 5.2 of the main text. Let PY stand for value added, WL for wage bill, and FS_L for the labor share defined as WL/PY. Our aim is to decompose the changes in the aggregate-level labor share to the shifts in the distribution of firms labor shares and the changes in market shares of firms along the distribution. Letting q denote a quantile of the labor share, we can write the aggregate-level labor share as

$$\overline{FS}_{L,t} \equiv \int_0^1 S_t\left(q\right)\, FS_{L,t}(q)\, dq, \tag{OA.6.1}$$

where $FS_{L,t}(q)$ is the average labor share of firms in the q-th quantile of the labor share distribution at time t and $S_k\left(q\right)$ denotes their share of aggregate added at time t. We can now decompose the change in the aggregate labor share as (Kehrig and Vincent, 2021):

$$\Delta\overline{FS}_t = \underbrace{\int_0^1 \widetilde{S}_{kt}\left(q\right)\, \Delta FS_t\left(q\right)\, dq}_{\text{Within quantile}} + \underbrace{\int_0^1 \Delta S_t\left(q\right)\, \widetilde{FS}_{L,t}\left(q\right)\, dq}_{\text{Across quantiles}}. \tag{OA.6.2}$$

The results presented in Figure 4a and Table 4 of the main paper report the accumulated values of the two components above from the initial year (1995) over time.

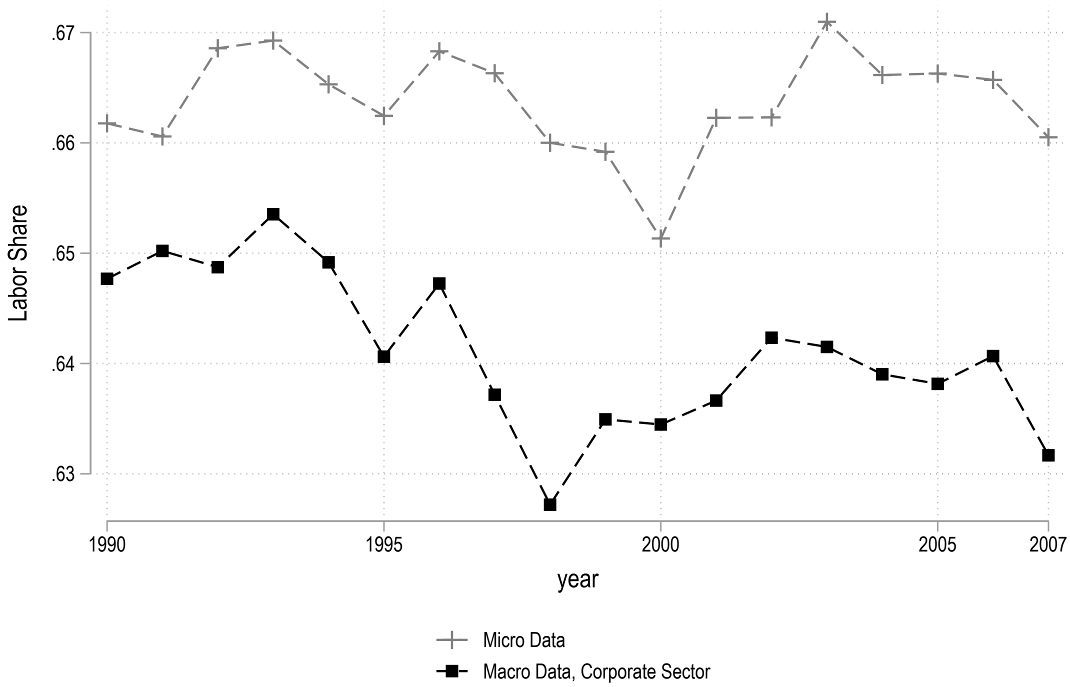
In Section OA.6.2 below, we provide a comparison of the aggregate labor share, as reported in the official statistics, and our micro data used for this decomposition.

OA.6.2 Macro vs Micro Labor Share

Table OA.1 reports the unweighted average value of labor share (across firms). It is fairly high and around 74%, similar between manufacturing and non-manufacturing, and does not show strong skewness (since mean and median values are fairly close).

Figure OA.4 reports the aggregate labor share in our data, defined as the value-added-weighted average labor share, compared to the aggregate labor share in the corporate sector in France reported by INSEE. We find an average aggregate labor share that is stable around 66% in our data, close to the macroeconomic data value of 64%. Differences are attributable to sectoral composition effects, as the macroeconomic data includes the

Figure OA.4: Aggregate Labor Share



Note: This figures reports the ratio of employee compensation, including payroll taxes, to total value-added in the market sectors in France. Micro data refers to the aggregate labor share in the BRN+RSI data, excluding observations with labor share higher than 3.3 and negative values. Macro data refers to the corporate sector in France, which includes sectors such as real estate, finance, and agriculture.

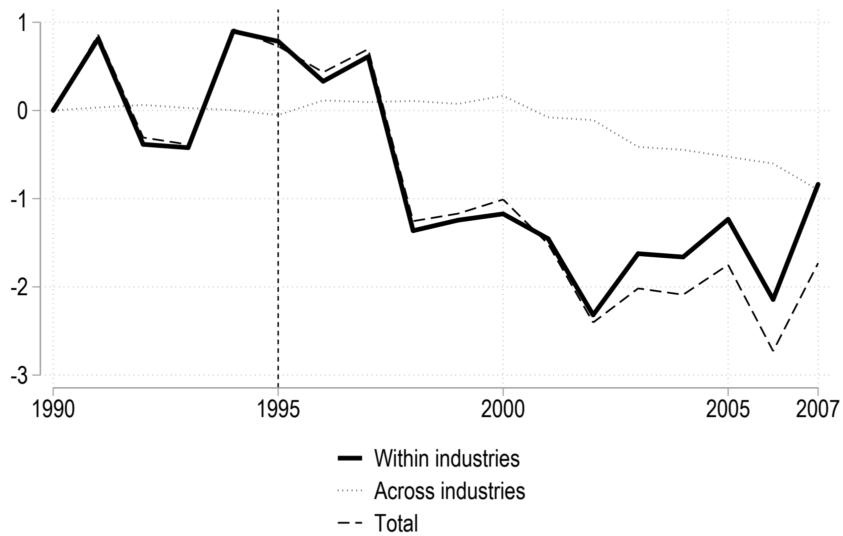
real estate, finance, and agriculture sectors that our data does not cover.[28] Sectoral data for the corporate sector only (excluding sole proprietorship firms) is not made public by INSEE.

OA.6.3 Aggregate Capital and Profit Share

Our model makes similar predictions about the evolution of capital share as it does about the labor share. To measure the capital share, the main challenge is how to distinguish economic profits from the returns to capital. Recent work has attempted to do this exercise at the aggregate level, relying on common assumptions about the trends in the aggregate returns to capital (Barkai, 2020). At the firm level, however, it is harder to justify the assumption that all firms face the same returns to capital. For the same reason, we cannot perform our within-versus-across firm decomposition in the case of capital share. Hence, we focus instead on showing that *the aggregate capital share, just like the aggregate labor share,*

[28] Cette et al. (2019) show that both the level and the sign of the variation of the aggregate labor share in France and other advanced economies varies depending on the sectoral composition.

Figure OA.5: Capital Share Decomposition



Note: This figure presents the cumulative change in the total capital share, as well as the decomposition of this change to within and across-industry components (at the level of A38 industries).

does not show a strong downward or upward trend during this period. Below, we present the results of our investigation of this question, following the methodology of Barkai (2020), and discuss their sensitivity to different measurement choices.

Figure OA.5 reports the cumulative *change* in the aggregate share of payments to capital, as well as the decomposition of this change to within and across-industry components. While the total capital share is slightly decreasing, this is mostly driven by sectoral reallocation towards low capital share industries. As with the case of the labor share, the capital share for the average industry remains mostly constant between 1990 and 2007.

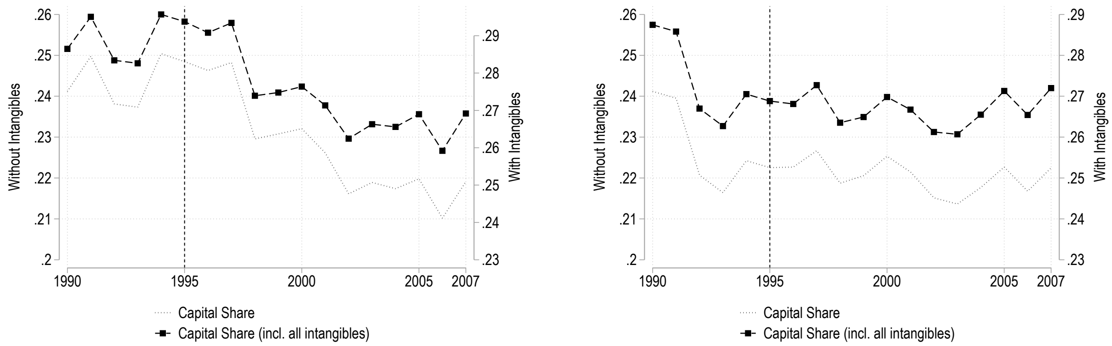
Computing the Capital Share To construct the values of capital share reported in Figure OA.5, we assume that the required returns to capital depend on the weighted average cost of capital, expected investment price inflation, depreciation, and tax rates (Barkai, 2020). For the purpose of this exercise, we compute the required rate of return on capital of type j according to the following formula

$$R_j = \left(\left(\frac{D}{D+E} i^D (1-\tau) + \frac{E}{D+E} i^E \right) - \mathbb{E}\left[\pi_j\right] + \delta_j \right) \frac{1 - z_j \tau}{1-\tau},$$

where D is the market value of debt, i^D is the debt cost of capital, E is the market value of equity, i^E is the equity cost of capital, τ is the corporate income tax rate, $\left(\frac{D}{D+E} i^D (1-\tau) + \frac{E}{D+E} i^E\right)$ is the weighted average cost of capital, π_j is the inflation rate of capital of type j, δ_j is the

Figure OA.6: Aggregate Capital Share

(a) Varying $\mathbb{E}\left[\pi_j\right]$ (b) Constant $\mathbb{E}\left[\pi_j\right]$



Note: This figure reports the ratio of payments to capital, to total value-added in the market sectors in France, excluding agriculture, finance and real estate. Capital share includes all intangible assets that are considerered as such in national accounts (software and databases, research and development, and intellectual property). Supplementary intangibles are marketing activities, design, training, and purchased and in-house organizational capital.

depreciation rate of capital of type j, and z_j is the net present value of depreciation allowances for capital of type j. We use data on corporate loan rates from the Banque de France, data on corporate tax rates from the OECD, and compute the cost of equity using data from Mazet-Sonilhac and Mesonnier (2016). The net present value of depreciation allowances are computed assuming exponential depreciation. We use the 2019 release of KLEMS (Adarov and Stehrer, 2019; Stehrer et al., 2019a) to account for the contribution of expenditure on intangibles assets that do not qualify as investment in national accounts, namely marketing activities, design, training, and purchased and in-house organizational capital. The expectation of investment price inflation is computed using 5-year moving averages.

Figure OA.6a reports the resulting *levels* of the aggregate capital share in France from 1990 to 2007. We find that the share of payments to productive capital including all supplementary intangible assets is broadly stable from 1998 to 2007. Because the data on supplementary intangible starts in 1995, we assume that the share of these supplementary intangibles was constant from 1990 to 1995. We find an early hump-shaped pattern whereby there is an initial rise from 1990 to 1998 and a subsequent fall from 1995 to 1998 that reverses the earlier rise. This hump is also visible in Figure OA.5 that documents the cumulative *change*.

This hump-shaped pattern is sensitive to the way we compute the expectation of investment price inflation. Figure OA.6b reports the evolution of the capital, assuming instead that the expected investment price inflation is constant over the period and equal

Table OA.15: Aggregate-Level Changes in France (1995-2007): Data vs. Model Predictions, Alternative Shock

Change in Aggregate Variable		Data	Model (Average DE-UK-US)	Model (correction)
Relative IT Price	W		-46.0%	-70.3%
Aggregate Output	$\overline{Y}$	19.1%	2.6%	5.0%
Price Index	$\overline{P}$	-15.7%	-2.5%	-4.8%
Share of Top 1% of Firms		6.3 p.p.	2.7 p.p.	5.2 p.p.
Share of Top 5% of Firms		4.0 p.p.	2.2 p.p.	4.2 p.p.
Labor Share	$\overline{FS}_L$	0.3 p.p.	-0.0 p.p.	-0.0 p.p.
Within contribution		1.3 p.p.	1.2 p.p.	2.3 p.p.
Between contribution		-1.0 p.p.	-1.2 p.p.	-2.3 p.p.
Profit Share		0.0 p.p.	0.0 p.p.	0.0 p.p.

Note: The table shows the changes in the French aggregate output, its price (relative to the bundle of non-IT inputs), and the profit share (based on the official INSEE series), and in the concentration of production and labor share (based on our macro data) over the 1995-2007 period. The changes are compared with those predicted by the model in response to two different series for falling relative IT prices: alternative series based on INSEE data using the average price of Computers in Germany, the UK and the US, and that including the correction by Byrne and Corrado (2017b). p.p. stands for "percentage points." % changes are expressed relative to the respective baseline in each model and in the data.

to the average investment price inflation from 1990 to 2007. We find a more stable capital share between 1990 and 1998. This is because investment price inflation relative to value-added price inflation fell sharply at the beginning of the 1990s but bounced back during the second half of the decade.

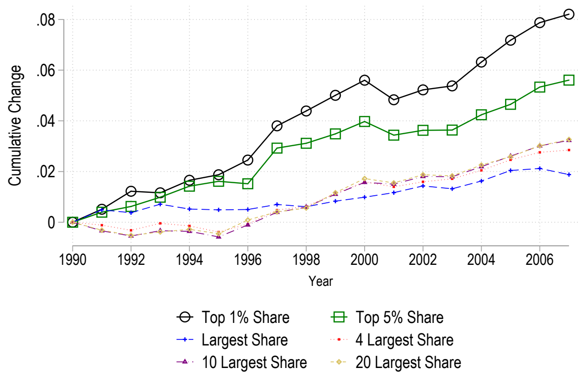
Overall, we conclude that the broad stability of the aggregate capital share is consistent with the broad stability of the aggregate labor share over the period, and with the model prediction that the total cost share has not fallen.

OA.6.4 General Equilibrium Results with Alternative IT Price Shock

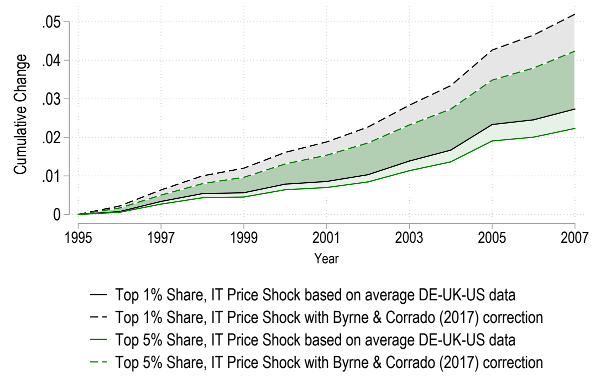
In Section OA.2.2.4 above, we discussed how alternative approaches to quality adjustments for computer prices lead to different estimates for the fall in the price of hardware in France compared to Germany, the UK and the US, and we construct an alternative measure for the fall in the relative price of IT in France that is based on the average of computer prices in these three countries. In this Section, we present the general equilibrium model predictions for aggregate-level changes under this alternative IT price shock (-46%), compared to what we observe in official INSEE statistics and to what we report under the baseline IT price shock (-27.9%) in Section 5 of the main draft. As with the baseline IT price shock, we compare predictions with the IT price shock as reported by official

Figure OA.7: Rise of Concentration in France: Data vs. Model Predictions, Alternative Shock

(a) Production Concentration in the Data



(b) Response of Concentration to IT Shock



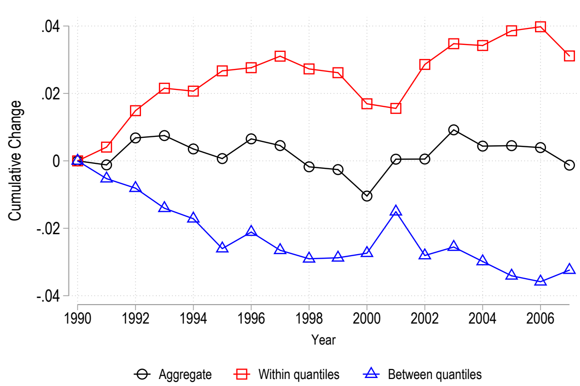
Note: Panel (a) presents the evolution of the sales-weighted averages (across 3-digits industries) of the cumulative change in concentration, measured as the share in total industry sales of the largest 1%, 5% , 1, 4, 10 or 20 firms. Panel (b) shows the cumulative changes in the shares of the largest 1% and 5% of firms predicted by the model in response to the two series for the relative IT prices over the 1995-2007 period.

statistics to predictions when we additionally incorporated the correction of Byrne and Corrado (2017b).

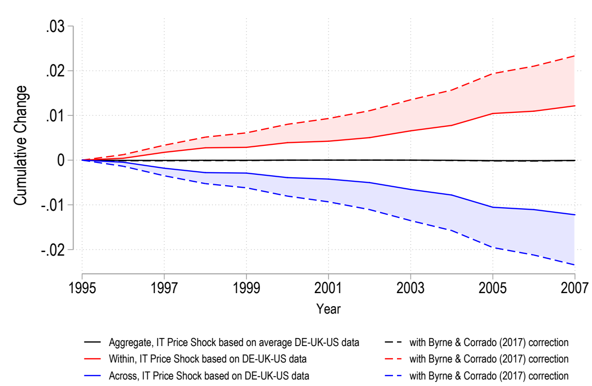
As shown in Table OA.15 and Figures OA.7 and OA.8, the model predicts stronger responses of aggregate output, inflation, concentration, and factor shares under the alternative shock than under the baseline shock, but the predictions of our framework remain qualitatively and quantitatively in line with the observed data.

Figure OA.8: Evolution of Labor Share in France: Data vs. Model Predictions, Alternative Shock

(a) Labor Share Decomposition



(b) Response of Labor Share to IT Shock



Note: Note. Panel (a) presents the cumulative change in the aggregate labor share, as well as the decomposition of this change to within and across-firm components (at the level of 2-digit industries). Panel (b) shows the correpsonding responses predicted by the model to the two series for the relative IT prices over the 1995-2007 period.

OA.7 Additional Tables

Table OA.16: Summary Statistics: Exporting vs All Firms

		All firms				Exporting firms			
	Source	Obs. (Nb)	Mean	Median	Sd	Obs. (Nb)	Mean	Median	Sd
Sales	BRN + RSI	15,202,793	2,498.8	265	85,057.3	1,773,652	12,592.8	1636	176,977.3
Value-Added	BRN + RSI	15,202,793	708.3	106	33,071.6	1,773,652	3,329.4	451.6	82,716.4
Number of Employees	BRN + RSI	15,202,793	13.8	3	480.7				
Wage Bill	BRN + RSI	15,202,793	472.4	74	18,404.6	1,773,652	2,107.2	345	46,396.1
Labor Share (%)	BRN + RSI	15,202,793	86.2	73.0	813.6	1,773,652	100.7	77.9	2,134.4
Total Investment	BRN	6,336,678	140.2	4.7	9,746.9	1,711,942	415.6	17	18,734.3
Total Capital Stock	BRN	6,336,678	1,205.9	88.6	92,054.5	1,711,942	3,706.8	230.3	176,922.7
Total Cost	BRN	6,336,677	888.2	180.3	33,090.3	1,711,942	2,339.8	368.1	63,154.2
IT Measures									
Software Investment	EAE	2,511,960	5.7	0	520.1	983,044	13.7	0	831.0
Software Stock	EAE	2,511,960	15.4	0	1,197.5	983,044	37.1	0	1,913.7
Hardware Investment	BRN	6,336,678	5.9	0	399.9	1,711,942	17.5	0	767.6
Hardware Stock	BRN	6,336,678	24.0	0	1,832.4	1,711,942	77.3	0.4	3,522.3
IT per Worker									
Software Investment	EAE	2,511,960	27.1	0	165.2	983,044	52.2	0	224.8
Software Stock	EAE	2,511,960	80.9	0	3,165.3	983,044	158.8	0	4,900.4
Hardware Investment	BRN	6,336,678	171.7	0	786.3	1,711,942	201.2	0	780.9
Hardware Stock	BRN	6,336,678	472.2	0	2,412.0	1,711,942	662.0	32.7	2,951.3
IT per Unit of Capital									
Software Investment	EAE	2,046,011	21.5	0	1,184.9	883,394	30.7	0	1,452.9
Software Stock	EAE	2,359,661	3.9	0	28.6	952,265	5.4	0	26.4
Hardware Investment	BRN	4,498,705	109.0	0	1,748.3	1,418,133	108.3	0	2,963.7
Hardware Stock	BRN	5,716,575	38.7	0	127.0	1,617,087	35.2	1.8	103.8
IT per Unit of Cost									
Software Investment	EAE	2,511,953	0.6	0	4.1	983,044	1.2	0	5.2
Software Stock	EAE	2,511,960	0.6	0	2.9	983,044	1.1	0	3.6
Hardware Investment	BRN	6,336,632	3.7	0	28.1	1,711,939	4.1	0	29.0
Hardware Stock	BRN	6,336,677	2.3	0	7.8	1,711,942	3.0	0.2	7.2

Note: The units for all variables are thousand euros except for those involving intensity, share, or numbers. The units for the IT intensity of labor, capital, and cost are euros per worker, euros per thousand euros of capital, and euros per thousand euros of cost, respectively. Labor share, in percentage points, is defined as the sum of wage bill and payroll taxes divided by value-added. Stock measures are built using the Perpetual Inventory Method (PIM), imputing zero investment for missing data. The table reports hardware and capital inputs for all firms included at least once in the BRN files, and software inputs for all firms surveyed at least once by EAE. Data Appendix B in the main text describes the sources for each variable. The period is 1990-2007 for BRN + RSI data, 1995-2007 for BRN and EAE data. For the IT intensity of capital, the number of non missing observations is lower because of the higher occurrence of zeros in the denominator.

Table OA.17: Depreciation Rates

	Software	Hardware	Machinery & Inst.	Intangible	Other Capital
Manufacturing	0.315	0.138	0.108	0.232	0.046
Construction	0.315	0.154	0.139	0.261	0.061
TTFA	0.315	0.184	0.127	0.312	0.057
ICT	0.315	0.185	0.115	0.245	0.047
Prof Serv	0.315	0.197	0.144	0.224	0.097
Non-Market	0.315	0.270	0.143	0.246	0.029
Other Serv	0.315	0.212	0.138	0.271	0.054
Total	0.315	0.192	0.130	0.256	0.056

Note: Manufacturing includes the Utility sector. Non-Market sectors are Government, Health and Education. TTFA refers to the Trade, Transportation, and Food and Accommodation sectors. Source: EU KLEMS.

Table OA.18: Representativeness of the Data

	Obs	Employment		Value Added		Investment	
	(Nb)	Total (K Persons)	Share (%)	Total (Bn €)	Share (%)	Total (Bn €)	Share (%)
1995	446,663.0	9,030.9	74.5	414.2	64.8	60.7	53.9
1996	452,177.0	9,078.0	74.6	415.1	64.2	59.5	50.8
1997	487,450.0	9,400.5	76.5	431.9	64.6	61.7	52.7
1998	484,779.0	9,719.3	77.2	457.8	64.9	61.2	47.7
1999	489,318.0	9,988.8	77.1	479.8	65.3	65.5	46.0
2000	495,692.0	10,462.8	77.4	510.8	65.4	77.2	49.3
2001	484,046.0	10,678.4	76.8	526.1	64.3	71.7	43.1
2002	498,036.0	10,827.7	77.3	542.3	64.3	69.0	42.0
2003	498,224.0	10,770.9	77.1	547.8	63.5	62.4	38.2
2004	501,654.0	10,839.9	77.6	569.5	63.8	71.6	42.3
2005	503,158.0	10,951.6	78.1	590.0	64.5	78.8	44.0
2006	508,879.0	11,083.6	78.4	618.7	65.1	73.3	38.6
2007	498,415.0	11,383.8	79.2	639.4	64.0	76.5	36.8
Total	6,348,491.0	134,216.1	77.1	6,743.4	64.5	889.0	44.1

Note: The sample is all firms that appear at least once in the BRN, excluding trimmed observations.

Table OA.19: Representativeness of the Raw Data

	Obs	Employment		Value Added		Investment	
	(Nb)	Total (K Persons)	Share (%)	Total (Bn €)	Share (%)	Total (Bn €)	Share (%)
1995	574,255.0	9,673.1	79.8	474.8	74.3	90.5	80.4
1996	576,450.0	9,742.6	80.0	478.1	74.0	88.9	76.0
1997	628,223.0	10,104.0	82.2	498.8	74.5	124.0	105.9
1998	631,055.0	10,459.5	83.0	530.1	75.1	101.7	79.3
1999	633,187.0	10,754.6	83.0	556.6	75.8	107.6	75.6
2000	639,025.0	11,285.1	83.5	595.7	76.3	129.4	82.6
2001	621,175.0	11,579.2	83.3	612.2	74.9	134.7	81.0
2002	647,997.0	11,740.5	83.8	643.2	76.3	125.8	76.6
2003	652,554.0	11,669.0	83.5	651.9	75.6	133.3	81.6
2004	662,496.0	11,768.2	84.2	681.6	76.4	136.2	80.4
2005	668,505.0	11,866.1	84.6	712.9	77.9	161.1	90.0
2006	682,668.0	12,035.2	85.1	746.4	78.6	145.4	76.6
2007	672,028.0	12,507.5	87.1	774.4	77.6	225.2	108.2
Total	8,289,618.0	145,184.5	83.4	7,956.7	76.1	1,703.8	84.6

Note: The sample is all firms that appear at least once in the BRN, including trimmed observations.

Table OA.20: Representativeness of firms with zero IT capital

	Obs	Employment		Value Added		Investment	
	(Nb)	Total (K Persons)	Share (%)	Total (Bn €)	Share (%)	Total (Bn €)	Share (%)
1995	317,355.0	2,383.7	19.7	85.9	13.4	10.1	9.0
1996	322,336.0	2,333.9	19.2	82.3	12.7	9.2	7.8
1997	353,330.0	2,434.8	19.8	85.2	12.7	9.8	8.4
1998	348,898.0	2,359.9	18.7	85.7	12.1	9.2	7.1
1999	351,236.0	2,374.1	18.3	88.7	12.1	10.0	7.0
2000	332,580.0	2,241.0	16.6	86.7	11.1	10.8	6.9
2001	296,821.0	1,999.6	14.4	79.8	9.8	8.1	4.9
2002	290,438.0	1,907.9	13.6	76.3	9.0	7.6	4.6
2003	238,693.0	1,458.4	10.4	58.9	6.8	4.8	2.9
2004	183,928.0	1,052.6	7.5	42.6	4.8	3.0	1.8
2005	150,005.0	847.1	6.0	35.3	3.9	2.2	1.2
2006	129,593.0	730.3	5.2	31.5	3.3	2.1	1.1
2007	104,119.0	719.8	5.0	28.6	2.9	2.1	1.0
Total	3,419,332.0	22,843.0	13.1	867.5	8.3	89.0	4.4

Note: The sample is all firms that appear at least once in the BRN with no software and hardware capital, excluding trimmed observations.

Table OA.21: Software Investment Summary Statistics (2006)

2006	Number of Firms				Average values		Median values
	All	EAE	No software investment	Some software investment	EAE	Some software investment	Some software investment
0-5	227,281	12,313	12,295	18	0.01	4.39	4.00
5-10	155,707	16,416	16,185	231	0.08	5.82	3.00
10-20	84,629	17,065	15,952	1,113	0.54	8.35	4.00
20-50	55,548	36,701	30,427	6,272	1.91	11.20	5.00
50-100	13,481	10,439	7,521	2,918	5.68	20.31	8.00
100-250	8,884	7,244	4,512	2,732	14.07	37.30	15.00
250-500	2,527	2,143	1,146	997	42.99	92.40	31.00
500-1000	1,065	937	463	474	108.66	214.80	80.00
1000-2500	560	487	215	272	226.92	406.28	163.50
2500-5000	146	130	58	72	884.48	1596.99	788.00
+5000	96	76	32	44	5515.61	9526.95	743.50

Note: The first column denotes the class size in terms of BRN employment. Columns (2)-(5) count the number of firms for each of the four samples, in each size class: all firms in 2006, firms sampled in EAE in 2006, of which firms that declared zero or missing software investment, and firms that declared positive software investment. Columns (6)-(7) display average software investment for all firms in EAE in 2006 and those that declared positive investment. Column (8) displays median software investment for firms that declared positive software investment.

Table OA.22: Hardware Investment Summary Statistics (1996)

1996	Number of Firms				Average values		Median values
	All	BRN	No hardware investment	Some hardware investment	BRN	Some hardware investment	Some hardware investment
0-5	214,156	170,345	168,931	1,307	0.02	2.94	1.52
5-10	135,664	122,186	119,216	2,855	0.10	4.32	2.13
10-20	58,170	56,465	53,882	2,515	0.30	6.87	3.05
20-50	48,896	48,786	43,840	4,878	1.63	17.00	7.01
50-100	11,392	11,392	8,368	2,976	8.41	33.90	15.55
100-250	7,200	7,200	3,390	3,769	33.34	67.39	31.56
250-500	2,173	2,173	479	1,684	115.87	149.86	74.85
500-1000	938	938	134	796	307.67	363.84	166.93
1000-2500	450	450	61	386	713.67	839.05	439.66
2500-5000	119	119	19	99	1832.74	2204.66	1061.35
+5000	55	55	9	46	12462.99	14901.40	2712.07

Note: The first column denotes the class size in terms of BRN employment. Columns (2)-(5) count the number of firms for each of the four samples, in each size class: all firms in 1996, firms sampled in BRN in 1996, of which firms that declared zero or missing hardware investment, and firms that declared positive hardware investment. Columns (6)-(7) display average hardware investment for all firms in BRN in 1996 and those that declared hardware investment. Column (8) displays median hardware investment for firms that declared positive hardware investment.

Table OA.23: Hardware Investment Summary Statistics (2006)

2006	Number of Firms				Average values		Median values
	All	BRN	No hardware investment	Some hardware investment	BRN	Some hardware investment	Some hardware investment
0-5	227,281	195,071	128,239	66,248	1.08	3.25	2.00
5-10	155,707	146,205	76,580	69,146	2.23	4.81	2.00
10-20	84,629	82,821	33,209	49,256	4.01	6.86	3.00
20-50	55,548	55,360	16,753	38,303	8.46	12.39	5.00
50-100	13,481	13,481	2,942	10,452	18.78	24.46	10.00
100-250	8,884	8,884	1,474	7,358	41.15	50.05	20.00
250-500	2,527	2,527	318	2,201	106.62	124.27	51.00
500-1000	1,065	1,065	137	924	206.65	239.18	113.00
1000-2500	560	560	68	487	586.07	701.21	295.00
2500-5000	146	146	15	130	1681.55	1892.44	950.50
+5000	96	96	16	80	5514.84	6617.81	1512.50

Note: The first column denotes the class size in terms of BRN employment. Columns (2)-(5) count the number of firms for each of the four samples, in each size class: all firms in 2006, firms sampled in BRN in 2006, of which firms that declared zero or missing hardware investment, and firms that declared positive hardware investment. Columns (6)-(7) display average hardware investment for all firms in BRN in 2006 and those that declared hardware investment. Column (8) displays median hardware investment for firms that declared positive hardware investment.

Table OA.24: Software Capital Summary Statistics (1996)

1996	Number of Firms				Average values		Median values
	All	EAE	No software capital	Some software capital	EAE	Some software capital	Some software capital
0-5	214,156	59,273	58,928	345	0.02	3.29	0.00
5-10	135,664	59,310	57,308	2,002	0.04	1.09	0.00
10-20	58,170	42,307	37,241	5,066	0.26	2.17	0.00
20-50	48,896	44,941	28,553	16,388	2.81	7.69	1.69
50-100	11,392	10,533	4,848	5,685	9.86	18.26	6.45
100-250	7,200	6,644	2,586	4,058	24.37	39.90	14.73
250-500	2,173	2,061	690	1,371	68.29	102.66	50.80
500-1000	938	915	270	645	200.88	284.97	120.21
1000-2500	450	445	123	322	486.89	672.87	287.69
2500-5000	119	118	36	82	960.78	1382.59	872.82
+5000	55	52	14	38	15072.99	20626.20	2359.80

Note: The first column denotes the class size in terms of BRN employment. Columns (2)-(5) count the number of firms for each of the four samples, in each size class: all firms in 1996, firms sampled in EAE in 1996, firms with zero or missing software PIM capital, and firms with positive software PIM capital. Columns (6)-(7) display average software PIM capital for all firms in EAE in 1996 and those with positive software PIM capital. Column (8) displays median software PIM capital for firms with positive software PIM capital.

Table OA.25: Software Capital Summary Statistics (2006)

2006	Number of Firms				Average values		Median values
	All	EAE	No software capital	Some software capital	EAE	Some software capital	Some software capital
0-5	227,281	49,933	49,103	830	0.03	2.06	0.39
5-10	155,707	50,272	47,161	3,111	0.16	2.56	0.84
10-20	84,629	43,547	34,413	9,134	0.84	4.00	1.27
20-50	55,548	45,487	22,608	22,879	4.87	9.69	2.97
50-100	13,481	11,645	3,455	8,190	16.04	22.81	7.26
100-250	8,884	7,910	1,800	6,110	42.78	55.38	18.88
250-500	2,527	2,293	433	1,860	131.86	162.56	53.11
500-1000	1,065	1,005	146	859	326.25	381.70	145.01
1000-2500	560	540	88	452	708.58	846.54	351.96
2500-5000	146	142	25	117	2726.67	3309.29	1076.51
+5000	96	91	19	72	16645.92	21038.59	1750.17

Note: The first column denotes the class size in terms of BRN employment. Columns (2)-(5) count the number of firms for each of the four samples, in each size class: all firms in 2006, firms sampled in EAE in 2006, firms with zero or missing software PIM capital, and firms with positive software PIM capital. Columns (6)-(7) display average software PIM capital for all firms in EAE in 2006 and those with positive software PIM capital. Column (8) displays median software PIM capital for firms with positive software PIM capital.

Table OA.26: Hardware Capital Summary Statistics (1996)

1996	Number of Firms				Average values		Median values
	All	BRN	No hardware capital	Some hardware capital	BRN	Some hardware capital	Some hardware capital
0-5	214,156	214,156	186,564	27,592	0.10	0.75	0.09
5-10	135,664	135,664	100,976	34,688	0.35	1.38	0.17
10-20	58,170	58,170	37,740	20,430	1.17	3.32	0.36
20-50	48,896	48,896	24,282	24,614	6.13	12.18	1.23
50-100	11,392	11,392	3,995	7,397	31.57	48.62	9.31
100-250	7,200	7,200	1,537	5,663	121.75	154.80	76.17
250-500	2,173	2,173	170	2,003	416.31	451.65	278.52
500-1000	938	938	38	900	1032.41	1076.00	652.81
1000-2500	450	450	13	437	2582.70	2659.53	1777.07
2500-5000	119	119	3	116	5818.59	5969.07	3622.89
+5000	55	55	3	52	44769.33	47352.18	11771.77

Note: The first column denotes the class size in terms of BRN employment. Columns (2)-(5) count the number of firms for each of the four samples, in each size class: all firms in 1996, firms sampled in BRN in 1996, firms with zero or missing hardware PIM capital, and firms with positive hardware PIM capital. Columns (6)-(7) display average hardware PIM capital for all firms in BRN in 1996 and those with positive hardware PIM capital. Column (8) displays median hardware PIM capital for firms with positive hardware PIM capital.

Table OA.27: Hardware Capital Summary Statistics (2006)

2006	Number of Firms				Average values		Median values
	All	BRN	No hardware capital	Some hardware capital	BRN	Some hardware capital	Some hardware capital
0-5	227,281	227,281	91,806	135,475	2.72	4.56	2.41
5-10	155,707	155,707	35,982	119,725	6.31	8.21	4.05
10-20	84,629	84,629	10,866	73,763	12.39	14.21	7.04
20-50	55,548	55,548	3,713	51,835	30.92	33.14	16.73
50-100	13,481	13,481	605	12,876	78.74	82.44	47.26
100-250	8,884	8,884	320	8,564	198.26	205.67	119.17
250-500	2,527	2,527	84	2,443	534.44	552.82	332.47
500-1000	1,065	1,065	28	1,037	1212.44	1245.18	699.05
1000-2500	560	560	21	539	2785.96	2894.50	1745.21
2500-5000	146	146	4	142	8070.12	8297.45	4535.24
+5000	96	96	3	93	39267.93	40534.64	11696.31

Note: The first column denotes the class size in terms of BRN employment. Columns (2)-(5) count the number of firms for each of the four samples, in each size class: all firms in 2006, firms sampled in BRN in 2006, firms with zero or missing hardware PIM capital, and firms with positive hardware PIM capital. Columns (6)-(7) display average hardware PIM capital for all firms in BRN in 2006 and those with positive hardware PIM capital. Column (8) displays median hardware PIM capital for firms with positive hardware PIM capital.

Table OA.28: Regressions of Log IT Per Employee on Log Firm Size, Clustered SEs

	Within-industry	
Panel 1: Software (Stock) per Employee		
Size (proxied by sales)	0.4034	
	(0.0269)	
Size (proxied by VA)		0.3933
		(0.0305)
Observations	557,728	557,793
Panel 1: Hardware (Stock) per Employee		
Size (proxied by sales)	0.6195	
	(0.0157)	
Size (proxied by VA)		0.5643
		(0.0172)
Observations	1,301,130	1,301,363

Note: In both panels the dependent variable is the logarithm of IT stock per employee. Standard errors are reported in brackets and are clustered at the 3-digit industry-level. The independent variable is the logarithm of firm size either proxied by sales or value added. The time period is 1995-2007. The sample is firms with at least 10 empoyees, in panel 1, sampled by EAE, and in panel 2, BRN firms. All columns include a full set of 3-digit industry classification fixed effects interacted with year fixed effects.

Table OA.29: Estimation Results for Cobb-Douglas Production Functions ($\epsilon = 0, \sigma = 1$)

		All Industries	Manufacturing
Non IT Capital Elasticity	γ_1	0.051	0.138
		(0.004)	(0.008)
Labor Elasticity	γ_2	0.772	0.699
		(0.010)	(0.018)
Software elasticity	γ_3	-0.034	0.026
		(0.010)	(0.010)
Hardware elasticity	γ_4	0.227	0.125
		(0.016)	(0.012)
Persistence of θ	$\rho_{\theta\theta}$	0.821	0.831
		(0.002)	(0.004)
Trend for θ	μ_θ	-0.004	0.001
		(0.001)	(0.001)
Shifter for θ	η_θ	0.667	0.560
		(0.011)	(0.016)
Observations	N	312981	150773

Note: Results of the estimation procedure with Cobb-Douglas production function $y_{it} = \gamma_1 k_{it} + \gamma_2 l_{it} + \gamma_3 s_{it} + \gamma_4 h_{it} + \widetilde{\theta}_{it}$ for the pooled sample of all firms, and for the pooled sample of manufacturing firms. For details, see Section 4.2 in the main text. Standard errors are reported in brackets.

Table OA.30: Estimation Results by Industry

	ϵ	σ	γ	α	β	N
Food products	0.875	0.469	0.949	0.261	0.119	20,117
	(0.059)	(0.040)	(0.012)	(0.015)	(0.112)	
Textiles	0.704	0.241	0.883	0.127	0.269	9,986
	(0.055)	(0.064)	(0.028)	(0.025)	(0.091)	
Wood, paper, and printing	0.618	0.083	0.956	0.143	0.128	18,021
	(0.060)	(0.063)	(0.012)	(0.013)	(0.067)	
Chemicals	0.525	0.405	0.949	0.143	0.000	6,342
	(0.105)	(0.073)	(0.036)	(0.042)	(0.208)	
Pharmaceuticals	0.136	0.424	0.838	0.000	-0.722	1,560
	(0.407)	(0.140)	(0.107)	(0.107)	(0.511)	
Rubber and plastic products	0.595	0.389	0.971	0.217	-0.388	15,658
	(0.208)	(0.179)	(0.012)	(0.014)	(0.403)	
Basic metals	0.613	0.074	0.978	0.164	0.218	30,911
	(0.049)	(0.040)	(0.007)	(0.008)	(0.035)	
Computers and electronics	0.463	0.014	1.006	0.148	0.365	5,690
	(0.158)	(0.193)	(0.031)	(0.042)	(0.150)	
Electrical equipments	0.364	0.446	0.955	0.039	0.000	4,024
	(0.119)	(0.115)	(0.035)	(0.050)	(0.316)	
Machinery and equipments	0.359	0.096	0.973	0.132	0.141	12,139
	(0.067)	(0.119)	(0.011)	(0.013)	(0.100)	
Transport equipments	0.495	0.117	0.951	0.103	0.191	6,068
	(0.043)	(0.062)	(0.014)	(0.021)	(0.107)	
Other manufacturing products	0.846	0.147	0.916	0.056	0.402	18,228
	(0.298)	(0.254)	(0.014)	(0.012)	(0.109)	
Mining, energy, and utilities	0.644	0.443	0.985	0.318	0.113	6,018
	(0.087)	(0.075)	(0.023)	(0.019)	(0.174)	
Construction	1.793	0.587	0.911	0.089	0.895	28,200
	(0.239)	(0.035)	(0.008)	(0.007)	(0.040)	
Wholesale and retail trade	0.058	0.065	0.949	0.063	0.003	60,592
	(0.016)	(0.018)	(0.009)	(0.012)	(0.017)	
Transportation	0.965	0.040	0.960	0.058	0.884	20,161
	(0.062)	(0.038)	(0.013)	(0.012)	(0.018)	
Accommodation and food services	0.619	0.014	0.946	0.163	0.895	7,014
	(0.086)	(0.037)	(0.012)	(0.011)	(0.034)	
Publishing and motion pictures	0.108	0.407	0.979	0.053	-0.894	6,559
	(0.186)	(0.108)	(0.023)	(0.019)	(0.372)	
ICT	0.522	0.068	0.933	0.092	0.929	4,701
	(0.129)	(0.107)	(0.017)	(0.020)	(0.036)	
Legal, accounting, and engineering	0.352	0.029	0.938	0.081	0.164	7,973
	(0.145)	(0.202)	(0.028)	(0.023)	(0.100)	
Research	0.197	0.462	0.937	0.062	-0.409	3,920
	(0.265)	(0.158)	(0.037)	(0.024)	(0.426)	
Administrative and support	2.917	0.130	0.733	0.059	0.792	13,622
	(0.246)	(0.214)	(0.053)	(0.012)	(0.087)	

Note: Results of our estimation procedure across 22 industries of the market economy (level A38 of the NAF classification) in France. For details, see Section OA.5.9 of this online appendix. Standard errors are reported in brackets.

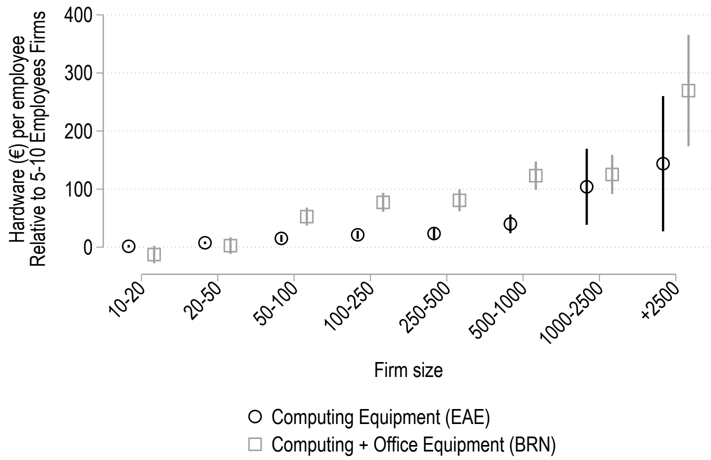
Table OA.31: Estimation Results by Industry, Linear Estimation

	ϵ	σ	γ	α	β	N
Food products	0.805	0.429	1.010	0.250	0.136	20,117
	(0.615)	(0.396)	(0.105)	(0.032)	(0.582)	
Textiles	0.491	0.291	1.018	0.052	-0.069	9,986
	(0.073)	(0.049)	(0.056)	(0.038)	(0.128)	
Wood, paper, and printing	0.647	0.115	0.992	0.148	0.093	18,021
	(0.391)	(0.484)	(0.240)	(0.045)	(0.456)	
Chemicals	0.557	0.554	1.000	0.206	-0.696	6,342
	(2.193)	(1.501)	(0.082)	(0.160)	(5.447)	
Pharmaceuticals	0.283	0.481	0.881	0.119	-0.423	1,560
	(0.407)	(0.452)	(0.094)	(0.189)	(0.911)	
Rubber and plastic products	0.830	0.370	1.023	0.203	0.031	15,658
	(0.085)	(0.117)	(0.047)	(0.024)	(0.294)	
Basic metals	0.615	0.043	1.010	0.155	0.266	30,911
	(0.150)	(0.176)	(0.005)	(0.011)	(0.102)	
Computers and electronics	0.439	-0.072	1.082	0.116	0.363	5,690
	(0.370)	(0.676)	(0.710)	(0.205)	(0.359)	
Electrical equipments	0.137	0.473	0.975	0.113	-0.448	4,024
	(0.290)	(0.583)	(0.042)	(0.065)	(1.540)	
Machinery and equipments	0.426	0.116	1.009	0.117	0.159	12,139
	(0.205)	(0.233)	(0.008)	(0.017)	(0.086)	
Transport equipments	0.509	0.078	0.994	0.119	0.315	6,068
	(0.047)	(0.089)	(0.109)	(0.030)	(0.164)	
Other manufacturing products	0.878	0.177	1.004	0.070	0.383	18,228
	(0.057)	(0.059)	(0.112)	(0.018)	(0.119)	
Mining, energy, and utilities	0.600	0.394	1.024	0.341	0.228	6,018
	(0.362)	(0.364)	(0.081)	(0.069)	(0.496)	
Construction	1.518	0.650	0.940	0.088	0.732	28,200
	(3.279)	(0.749)	(0.096)	(0.013)	(0.571)	
Wholesale and retail trade	0.132	0.189	0.969	0.060	-0.180	60,592
	(0.014)	(0.022)	(0.008)	(0.016)	(0.037)	
Transportation	0.502	-0.519	1.039	0.054	0.913	20,161
	(0.248)	(0.626)	(0.983)	(0.018)	(0.023)	
Accomodation and food services	0.274	-0.703	0.956	0.160	0.918	7,014
	(0.210)	(0.883)	(0.119)	(0.026)	(0.036)	
Publishing and motion pictures	0.705	0.470	0.941	0.061	-0.439	6,559
	(1.004)	(0.688)	(0.100)	(0.061)	(1.816)	
ICT	0.511	0.008	1.001	0.073	0.938	4,701
	(0.174)	(0.317)	(0.523)	(0.073)	(0.057)	
Legal, accounting, and engineering	0.335	-0.021	0.987	0.093	0.200	7,973
	(0.086)	(0.204)	(1.014)	(0.043)	(0.150)	
Research	1.142	0.638	0.952	0.072	0.087	3,920
	(2.997)	(0.970)	(0.302)	(0.041)	(2.561)	
Administrative and support	0.404	0.597	0.989	0.003	0.251	13,622
	(0.855)	(0.306)	(0.084)	(0.063)	(0.470)	

Note: Results of the third step of our estimation procedure across 22 industries of the market economy (level A38 of the NAF classification) in France, with the log-linearized production function. For details, see Section OA.5.9 of this online appendix. Standard errors are reported in brackets.

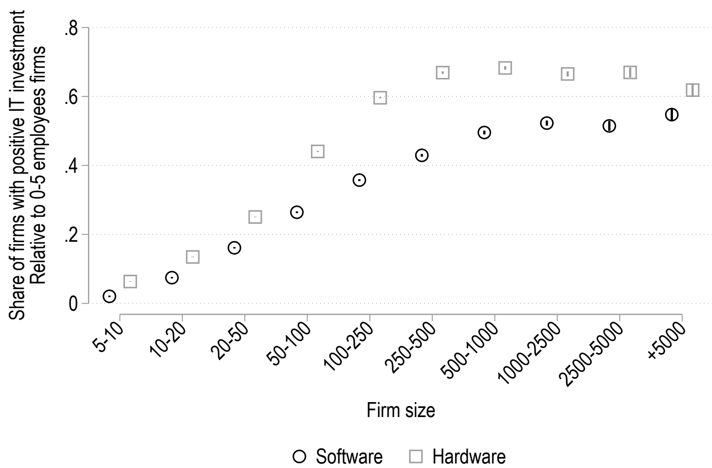
OA.8 Additional Figures

Figure OA.9: Cross-sectional Relationship Between Size and Computing relative to Total or Hardware Investment.



Note: This figure reports the conditional average of EAE computing investment, excluding non-IT office furniture, and BRN hardware investment, including non-IT office furniture, relative to the number of employees, by firm size. Averages are conditional on a set of flexible fixed effects constructed from the interaction of 3-digit industry codes and time dummies, and a full set of cohorts fixed effect (pre-1980, 1980-1993, 1993-1995, ..., 2005-2007) and normalized age fixed effects. The sample includes all firms sampled in EAE for which that question was asked, 90% of which are in the AgriFood industry. The bands around the estimates show the 90% confidence intervals. Standard errors are robust to heteroskedasticity.

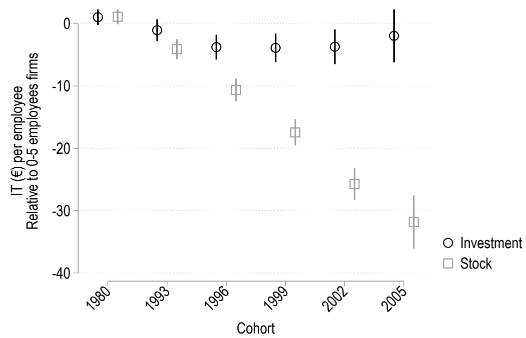
Figure OA.10: Cross-sectional Relationship Between Extensive Margin of Investment and Firm Size



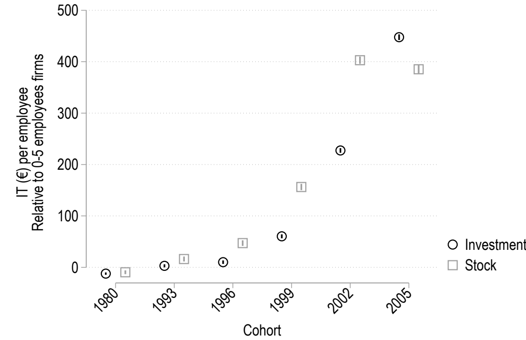
Note: This figure reports the proportion of firms with positive IT investment by firm size. Proportions are conditional on a set of flexible fixed effects constructed from the interaction of 4-digit industry codes and time dummies.

Figure OA.11: Cross-sectional Relationship Between IT and Firm Cohort

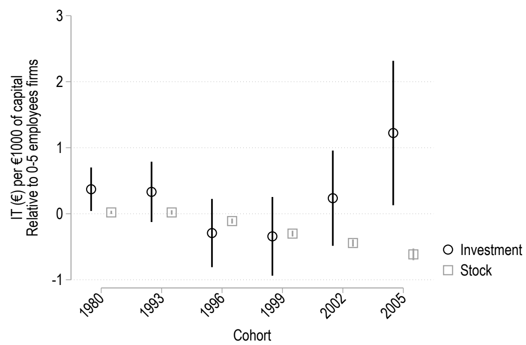
(a) Software per Unit of Labor



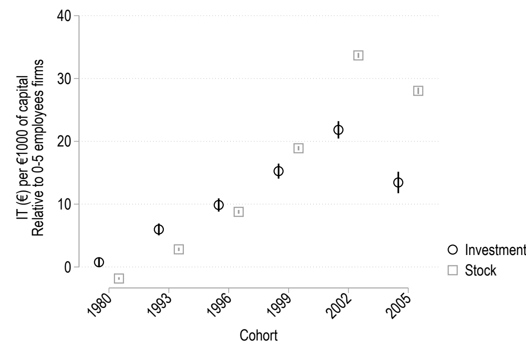
(b) Hardware per Unit of Labor



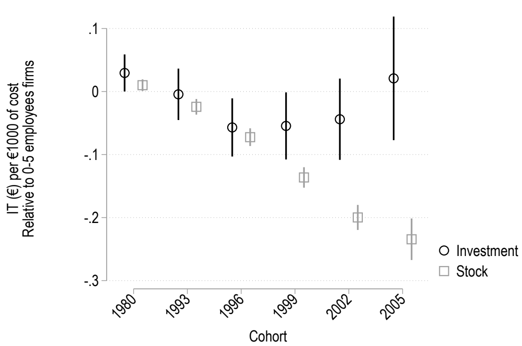
(c) Software per Unit of Capital



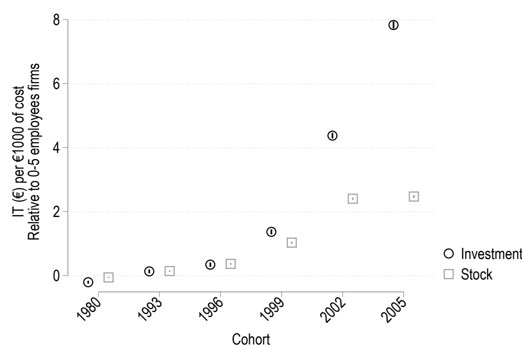
(d) Hardware per Unit of Capital



(e) Software per Unit of Costs



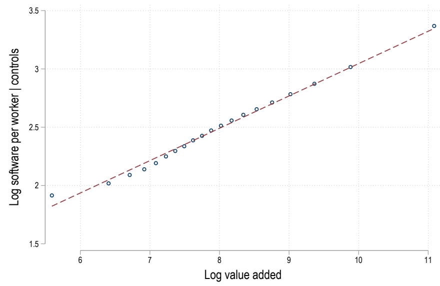
(f) Hardware per Unit of Costs



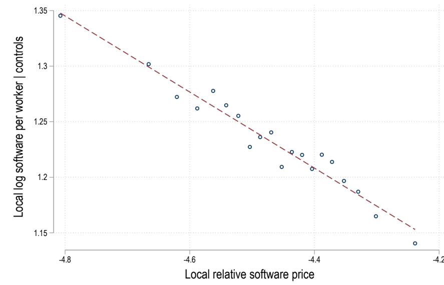
Note: This figure reports the average of relative IT demand by firm cohort. Averages are conditional on a set of flexible fixed effects constructed from the interaction of 3-digit industry codes and time dummies, and a full set of cohorts fixed effect (pre-1980, 1980-1993, 1993-1995, ..., 2005-2007) and normalized age fixed effects. In the case of software, the sample includes all firms that were sampled in EAE (that year for investment, at least once for capital). In the case of hardware, the sample includes all firms that reported hardware investment lower than 0.99 times total investment. The units for the IT intensity of labor, capital, and cost are euros per worker, euros per thousand euros of capital, and euros per thousand euros of cost, respectively. Imputed values of the "investment" measures are dropped from the analysis. The bands around the estimates show the 90% confidence intervals.

Figure OA.12: Identification of Scale-Dependence (ϵ) and Elasticity of Substitution (σ)

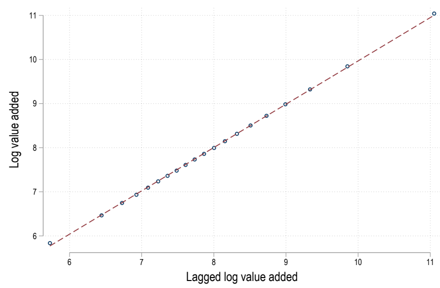
(a) OLS, ϵ



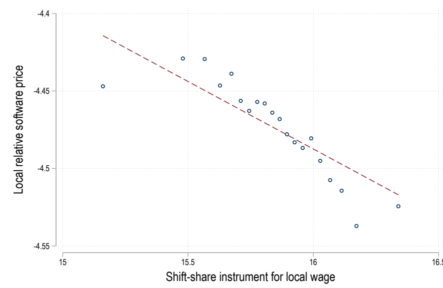
(b) OLS, σ



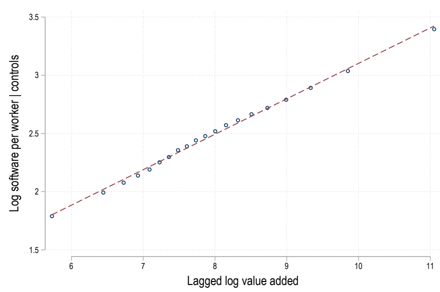
(c) First Stage, ϵ



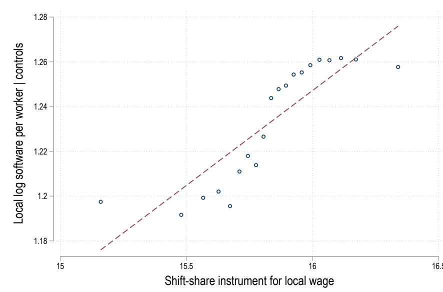
(d) First Stage, σ



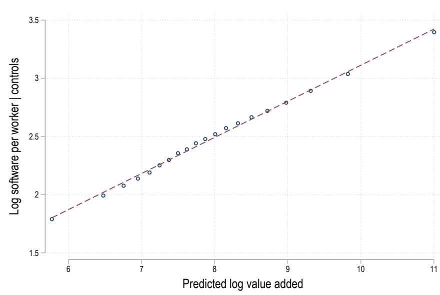
(e) Reduced Form, ϵ



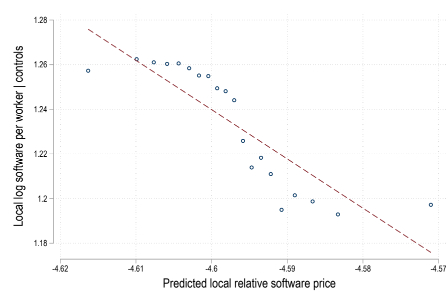
(f) Reduced Form, σ



(g) Second Stage, ϵ

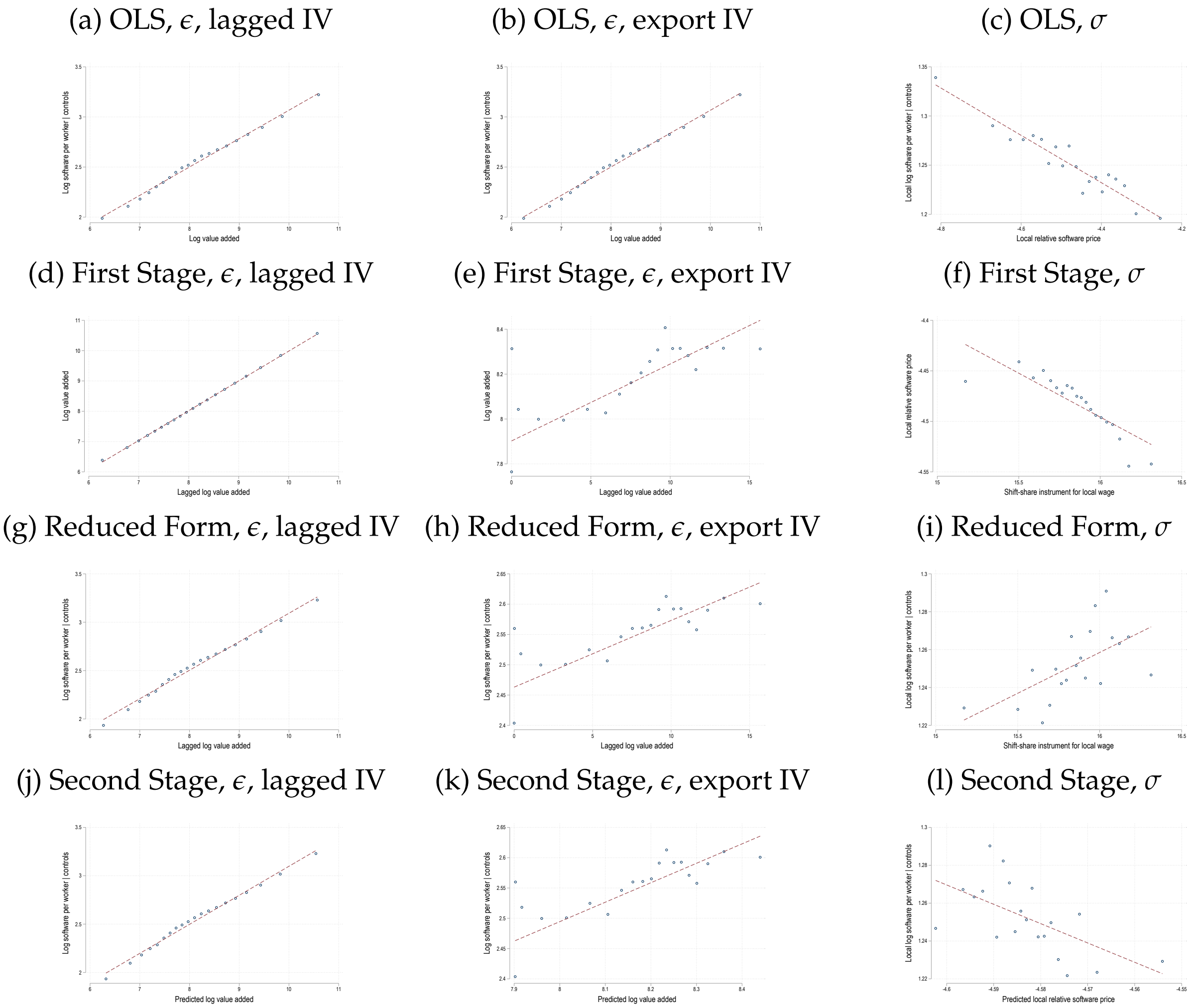


(h) Second Stage, σ



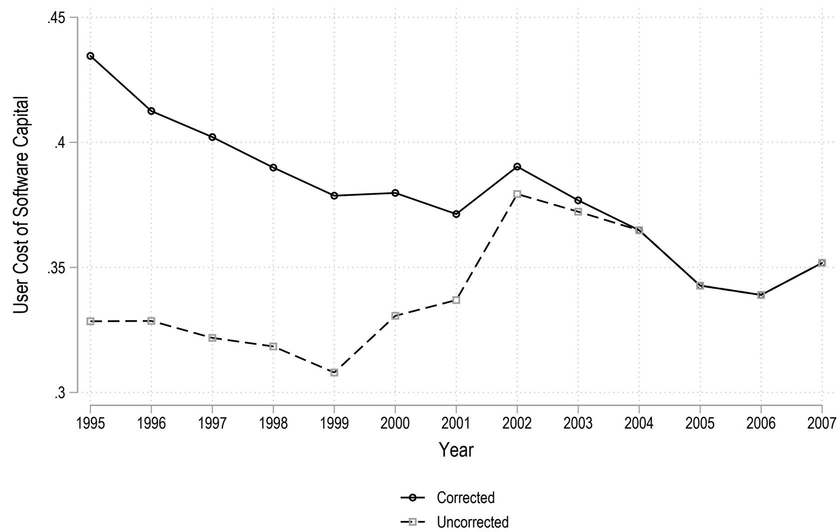
Note: This figure reports the relationships in the data between software stock per worker (minus the controls), and the logarithms of value added and relative price of software, and their respective instruments, the logarithm of lagged value added and the shift-share instrument for local labor demand. In the first and in the second columns, OLS corresponds to a simple regression of software stock per worker (minus the controls) on RHS (corresponding to Equations OA.5.7 and OA.5.6, respectively), first stage to a regression of RHS on its instrument, reduced form to a regression of software stock per worker (minus the controls) on the instrument, and second stage to a regression of software stock per worker (minus the controls) on the predicted value of RHS from the first stage. The 95% confidence intervals drawn correspond to prediction intervals, including both the standard error around the slope and the variance of residuals. For the identification of σ, firms' outcomes are averaged at the local $\times$ year level and regressions are weighted by the number of firms at each location $\times$ year. The sample of firms corresponds to the estimation results reported in Table 2 (all industries).

Figure OA.13: Structural Identification of Scale-dependence (ϵ) and Elasticity of Substitution (σ), Exporting Firms



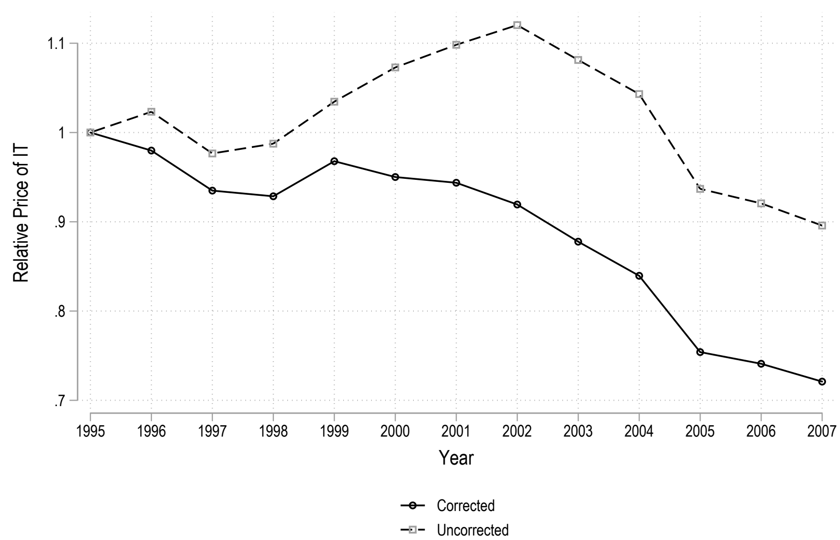
Note: This figure reports the relationships in the data between software stock per worker (minus the controls), and the logarithms of value added and relative price of software, and their respective instruments. In the first colmun, the logarithm of value added is instrumented by lagged logarithmn valued added and in the second by the export demand shock. In the third column, relative price of software is instrumented by the shift-share instrument for local labor demand. In all columns, OLS corresponds to a simple regression of software stock per worker (minus the controls) on RHS (corresponding to Equations OA.5.7 and OA.5.6, respectively), first stage to a regression of RHS on its instrument, reduced form to a regression of software stock per worker (minus the controls) on the instrument, and second stage to a regression of software stock per worker (minus the controls) on the predicted value of RHS from the first stage. The 95% confidence intervals drawn correspond to prediction intervals, including both the standard error around the slope and the variance of residuals. For the identification of σ, firms' outcomes are averaged at the local $\times$ year level and regressions are weighted by the number of firms at each location $\times$ year. The sample, exporting firms, is narrower than in the estimation results reported in Table 2.

Figure OA.14: Rental Price of Software



Note: This figure presents the value of the user cost of software capital with and without the additional quality adjustment to the INSEE series discussed in Section OA.2.2 (page 19). The unadjusted measure directly uses the price of software investment reported by INSEE National Accounts. The adjusted measure assumes that the price of software investment before 2002 followed the same trend as from 2002 to 2014.

Figure OA.15: Relative Price of IT Bundle to non-IT Bundle



Note: This figure presents the value of the relative price of the bundle of IT inputs to the bundle of non-IT inputs with and without the additional quality adjustment to the INSEE series for the price of software discussed in Section OA.2.2 (page 19). The unadjusted measure directly uses the price of software investment reported by INSEE National Accounts. The adjusted measure assumes that the price of software investment before 2002 followed the same trend as from 2002 to 2014.

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Information Technology and Returns to Scale

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Supplementary Online Appendix: Alternative vs. Benchmark Data Construction.

Abstract

This supplementary online appendix presents the results under an alternative data construction, which relies on fewer confidential data sources and is more easily reproducible based on the data available to researchers outside INSEE.

Section OA.2 of our main Online Appendix provides further details about the sources of data used in the analysis. Among these sources, the BIC and ESANE files are not currently accessible to researchers outside INSEE. In Section OA.2.5.1 of our main Online Appendix we present an alternative data construction that circumvents the use of the BIC and ESANE files.

This supplementary Online Appendix shows that our results are robust to this alternative data construction, by comparing all tables and figures in the alternative version of the paper to those in the benchmark version.

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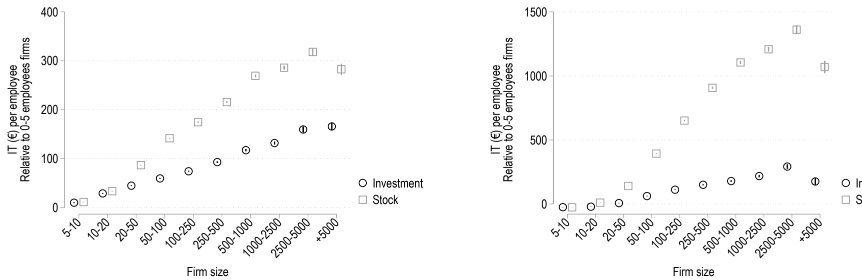
2 Motivating Fact: Firm Scale and Relative IT Demand

Figure 1: Cross-sectional Relationship Between IT and Firm Size, Benchmark

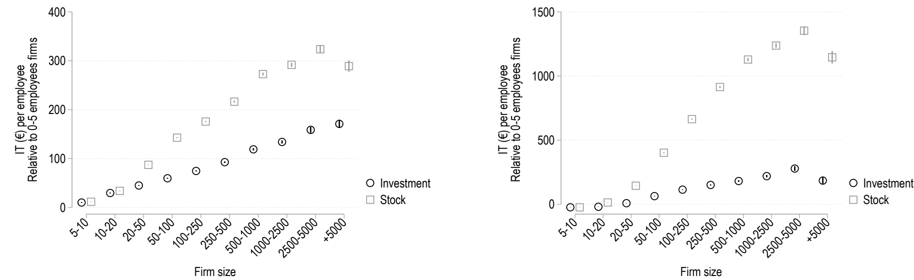
(a) Software per employee (b) Hardware per employee



Note: This figure reports average IT investment and stock per employee by firm size class. Averages are conditional on a set of flexible fixed effects constructed from the interaction of 3-digit industry codes and time dummies, and a full set of cohorts fixed effect (pre 1980, 1980-1993, 1993-1995 ... 2005-2007) and normalized age fixed effects. In the case of software, the sample is all firms that were sampled in EAE (that year for investment, at least once for capital). In the case of hardware, the sample is all firms that reported hardware investment lower than 0.99 times total investment. The bands around the estimates show the 90% confidence intervals.

Figure 1: Cross-sectional Relationship Between IT and Firm Size, Alternative

(a) Software per employee (b) Hardware per employee



Note: This figure reports average IT investment and stock per employee by firm size class. Averages are conditional on a set of flexible fixed effects constructed from the interaction of 3-digit industry codes and time dummies, and a full set of cohorts fixed effect (pre 1980, 1980-1993, 1993-1995 ... 2005-2007) and normalized age fixed effects. In the case of software, the sample is all firms that were sampled in EAE (that year for investment, at least once for capital). In the case of hardware, the sample is all firms that reported hardware investment lower than 0.99 times total investment. The bands around the estimates show the 90% confidence intervals.

Table 1: Regressions of Log IT Demand on Log Firm Size, Benchmark

	Within-industry		Within-firm	
Panel 1: Software (Stock) per Employee				
Size (proxied by sales)	0.4131		0.2138	
	(0.0033)		(0.0328)	
Size (proxied by VA)		0.4092		0.2224
		(0.0036)		(0.0289)
Observations	556,996	557,059	236,510	236,617
Panel 1: Hardware (Stock) per Employee				
Size (proxied by sales)	0.6249		0.2681	
	(0.0013)		(0.0097)	
Size (proxied by VA)		0.5780		0.1520
		(0.0014)		(0.0082)
Observations	1,299,964	1,300,197	249,933	250,935

Note: In both panels the dependent variable is the logarithm of IT stock per employee. Standard errors are reported in brackets. The independent variable is the logarithm of firm size either proxied by sales or value added. The time period is 1995-2007. The sample is firms with at least 10 empoyees, in panel 1, sampled by EAE, and in panel 2, BRN firms. All columns include a full set of 3-digit industry classification fixed effects interacted with year fixed effects, and within-industry results also include a full set of cohorts fixed effect (pre 1980, 1980-1993, 1993-1995 ... 2005-2007) and normalized age fixed effects. An elasticity of 0.4 means that raising sales by a factor of 2 raises IT per employee by 40%. IV estimates are weighted by the share of each firm's exports in its total sales in 1995-1996.

Table 1: Regressions of Log IT Demand on Log Firm Size, Alternative

	Within-industry		Within-firm	
Panel 1: Software (Stock) per Employee				
Size (proxied by sales)	0.4207		0.2308	
	(0.0033)		(0.0334)	
Size (proxied by VA)		0.4110		0.2224
		(0.0036)		(0.0294)
Observations	571,304	571,380	245,747	245,768
Panel 1: Hardware (Stock) per Employee				
Size (proxied by sales)	0.6214		0.2551	
	(0.0013)		(0.0095)	
Size (proxied by VA)		0.5744		0.1462
		(0.0014)		(0.0080)
Observations	1,314,569	1,314,830	257,162	258,173

Note: In both panels the dependent variable is the logarithm of IT stock per employee. Standard errors are reported in brackets. The independent variable is the logarithm of firm size either proxied by sales or value added. The time period is 1995-2007. The sample is firms with at least 10 empoyees, in panel 1, sampled by EAE, and in panel 2, BRN firms. All columns include a full set of 3-digit industry classification fixed effects interacted with year fixed effects, and within-industry results also include a full set of cohorts fixed effect (pre 1980, 1980-1993, 1993-1995 ... 2005-2007) and normalized age fixed effects. An elasticity of 0.4 means that raising sales by a factor of 2 raises IT per employee by 40%. IV estimates are weighted by the share of each firm's exports in its total sales in 1995-1996.

4 Estimation: Scale-Dependent Production Function

Table 2: Estimation Results, Benchmark

		All Industries	Manufacturing
Scale-dependence paramater	ϵ	0.433	0.466
		(0.026)	(0.027)
Elasticity of substitution	σ	0.280	0.131
		(0.034)	(0.036)
Cost elasticity parameter	γ	0.939	0.946
		(0.004)	(0.006)
Capital elasticity of non-IT	α	0.062	0.146
		(0.003)	(0.007)
Software elasticity of IT	β	0.042	0.152
		(0.034)	(0.034)
Observations	N	307504	148979

Note: Results of the estimation procedure for the pooled sample of all firms in and for the pooled sample of manufacturing firms. Standard errors are reported in brackets.

Table 2: Estimation Results, Alternative

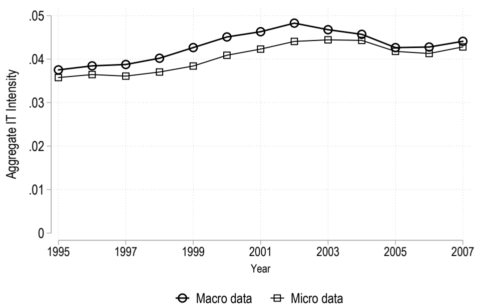
		All Industries	Manufacturing
Scale-dependence paramater	ϵ	0.422	0.542
		(0.010)	(0.012)
Elasticity of substitution	σ	0.264	0.252
		(0.013)	(0.015)
Cost elasticity parameter	γ	0.946	0.950
		(0.004)	(0.005)
Capital elasticity of non-IT	α	0.068	0.139
		(0.004)	(0.006)
Software elasticity of IT	β	0.003	0.002
		(0.023)	(0.034)
Observations	N	310229	157357

Note: Results of the estimation procedure for the pooled sample of all firms in and for the pooled sample of manufacturing firms. Standard errors are reported in brackets.

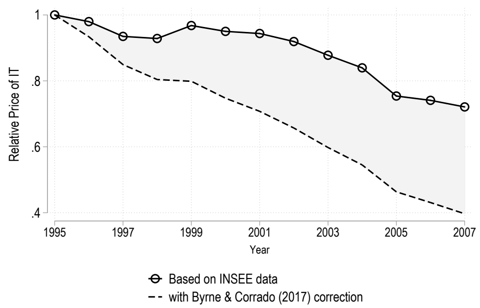
5 Empirical Application: Macro Trends in France

Figure 2: The Evolution of IT Intensity and Prices in France, Benchmark

(a) Aggregate IT Intensity: Macro vs. Micro Data



(b) Fall in Relative IT Prices



Note: Panel (a) presents the aggregate IT intensity of the French economy, defined as the ratio of the payments to IT relative to all factor payments, based on INSEE National Account data (macro) and based on the calibrated dataset that maps our micro-level data to the French macroeconomy (micro) (Sources: EU KLEMS/RSI+BRN+EAE Data). Panel (b) presents the evolution of relative price of IT for France constructed based on the INSEE National Accounts data, and that constructed by incorporating a correction based on the estimates of Byrne and Corrado (2017) for the bias in the official prices of IT investment goods in the US data.

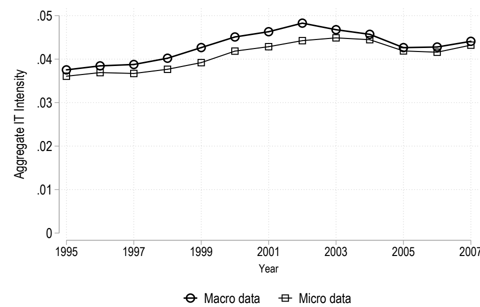
Table 3: Aggregate Technological Elasticities, Benchmark

Aggregate Variable		1995	2007	Average
IT Intensity	$\overline{\Omega}_I$	0.036	0.043	0.040
Cost Elasticity	$\overline{\mathcal{E}}$	0.954	0.957	0.956
Pass-Through	$\overline{\Omega}_I^m$	0.035	0.043	0.040
Marginal Cost Elasticity	$\overline{\mathcal{E}}^m$	-0.046	-0.043	-0.044
Elasticity of Substitution	$\overline{\sigma}_I$	1.066	0.997	1.002
Within contribution		0.235	0.241	0.242
Between contribution		0.831	0.756	0.761
Output Elasticity of Relative IT Demand	$\overline{\eta}_I$	-0.029	0.001	-0.001
Within contribution		0.262	0.268	0.269
Between contribution		-0.291	-0.266	-0.270
Normalized IT Intensity Variance	ν_I	0.159	0.140	0.137
IT Intensity Variance	$\mathbb{V}^c\left[\Omega_{j,i}\right]$	0.005	0.006	0.005
Pass-Through Variance	$\mathbb{V}^p\left[\Omega_{j,i}^m\right]$	0.005	0.005	0.005
IT Intensity-Cost Elasticity Covariance	$\mathbb{C}^c\left[\Omega_{j,i},\mathcal{E}_i\right]$	0.002	0.002	0.002
Pass-Through-Marginal Cost Elasticity Covariance	$\mathbb{C}^p\left[\Omega_{j,i}^m,\mathcal{E}_i^m\right]$	0.002	0.002	0.002

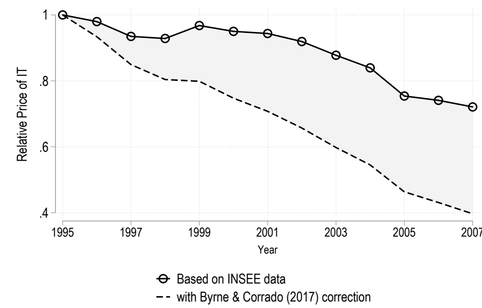
Note: The table shows the aggregate technological elasticites calculated based on applying our aggregation results to the calibrated dataset, in the first (1995), the last year (2007), and the average across all years (1995-2007) of the data.

Figure 2: The Evolution of IT Intensity and Prices in France, Alternative

(a) Aggregate IT Intensity: Macro vs. Micro Data



(b) Fall in Relative IT Prices



Note: Panel (a) presents the aggregate IT intensity of the French economy, defined as the ratio of the payments to IT relative to all factor payments, based on INSEE National Account data (macro) and based on the calibrated dataset that maps our micro-level data to the French macroeconomy (micro) (Sources: EU KLEMS/RSI+BRN+EAE Data). Panel (b) presents the evolution of relative price of IT for France constructed based on the INSEE National Accounts data, and that constructed by incorporating a correction based on the estimates of Byrne and Corrado (2017) for the bias in the official prices of IT investment goods in the US data.

Table 3: Aggregate Technological Elasticities, Alternative

Aggregate Variable		1995	2007	Average
IT Intensity	$\overline{\Omega}_I$	0.036	0.043	0.041
Cost Elasticity	$\overline{\mathcal{E}}$	0.961	0.964	0.963
Pass-Through	$\overline{\Omega}_I^m$	0.034	0.044	0.041
Marginal Cost Elasticity	$\overline{\mathcal{E}}^m$	-0.039	-0.035	-0.037
Elasticity of Substitution	$\overline{\sigma}_I$	1.114	0.968	1.004
Within contribution		0.217	0.226	0.225
Between contribution		0.897	0.742	0.778
Output Elasticity of Relative IT Demand	$\overline{\eta}_I$	-0.048	0.014	-0.002
Within contribution		0.255	0.265	0.265
Between contribution		-0.302	-0.251	-0.266
Normalized IT Intensity Variance	ν_I	0.180	0.146	0.147
IT Intensity Variance	$\mathbb{V}^c\left[\Omega_{j,i}\right]$	0.006	0.006	0.006
Pass-Through Variance	$\mathbb{V}^p\left[\Omega_{j,i}^m\right]$	0.005	0.005	0.005
IT Intensity-Cost Elasticity Covariance	$\mathbb{C}^c\left[\Omega_{j,i},\mathcal{E}_i\right]$	0.003	0.003	0.002
Pass-Through-Marginal Cost Elasticity Covariance	$\mathbb{C}^p\left[\Omega_{j,i}^m,\mathcal{E}_i^m\right]$	0.002	0.002	0.002

Note: The table shows the aggregate technological elasticites calculated based on applying our aggregation results to the calibrated dataset, in the first (1995), the last year (2007), and the average across all years (1995-2007) of the data.

Table 4: Aggregate-Level Changes in France (1995-2007): Data vs. Model Predictions, Benchmark

Change in Aggregate Variable		Data	Model (INSEE)	Model (correction)
Relative IT Price	W		-27.9%	-60.3%
Aggregate Output	$\overline{Y}$	19.1%	1.4%	3.9%
Price Index	$\overline{P}$	-15.7%	-1.4%	-3.7%
Share of Top 1% of Firms		6.3 p.p.	1.5 p.p.	4.1 p.p.
Share of Top 5% of Firms		4.0 p.p.	1.3 p.p.	3.3 p.p.
Labor Share	$\overline{FS}_L$	0.3 p.p.	-0.0 p.p.	-0.0 p.p.
Within contribution		1.3 p.p.	0.7 p.p.	1.8 p.p.
Between contribution		-1.0 p.p.	-0.7 p.p.	-1.8 p.p.
Profit Share		-0.0 p.p.	0.0 p.p.	0.0 p.p.

Note: The table shows the changes in the French aggregate output, its price (relative to the bundle of non-IT inputs), and the profit share (based on the official INSEE series), and in the concentration of production and labor share (based on our macro data) over the 1995-2007 period. The changes are compared with those predicted by the model (based on the calibrated dataset) in response to two different series for falling relative IT prices: baseline series based on INSEE data, and that including the correction by Byrne and Corrado (2017). p.p. stands for "percentage points." % changes are expressed relative to the respective baseline in each model and in the data.

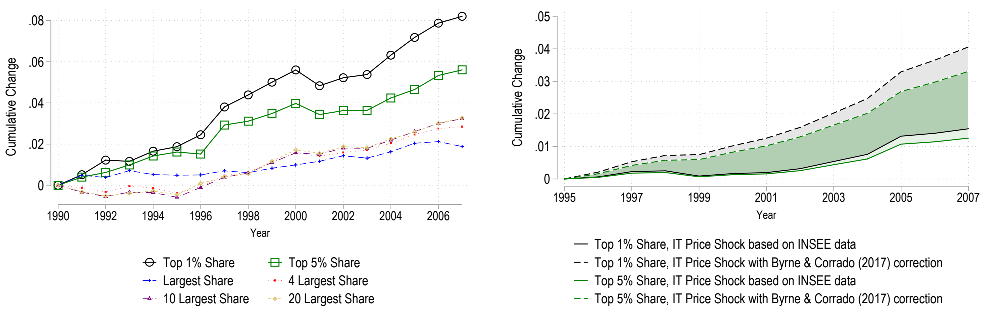
Table 4: Aggregate-Level Changes in France (1995-2007): Data vs. Model Predictions, Alternative

Change in Aggregate Variable		Data	Model (INSEE)	Model (correction)
Relative IT Price	W		-27.9%	-60.3%
Aggregate Output	$\overline{Y}$	19.1%	1.4%	3.9%
Price Index	$\overline{P}$	-15.7%	-1.4%	-3.7%
Share of Top 1% of Firms		6.9 p.p.	1.3 p.p.	3.4 p.p.
Share of Top 5% of Firms		4.1 p.p.	1.0 p.p.	2.7 p.p.
Labor Share	$\overline{FS}_L$	-0.0 p.p.	-0.0 p.p.	-0.0 p.p.
Within contribution		1.4 p.p.	0.7 p.p.	1.8 p.p.
Between contribution		-1.4 p.p.	-0.7 p.p.	-1.8 p.p.
Profit Share		0.3 p.p.	-0.0 p.p.	0.0 p.p.

Note: The table shows the changes in the French aggregate output, its price (relative to the bundle of non-IT inputs), and the profit share (based on the official INSEE series), and in the concentration of production and labor share (based on our macro data) over the 1995-2007 period. The changes are compared with those predicted by the model (based on the calibrated dataset) in response to two different series for falling relative IT prices: baseline series based on INSEE data, and that including the correction by Byrne and Corrado (2017). p.p. stands for "percentage points." % changes are expressed relative to the respective baseline in each model and in the data.

Figure 3: Rise of Concentration in France: Data vs. Model Predictions, Benchmark

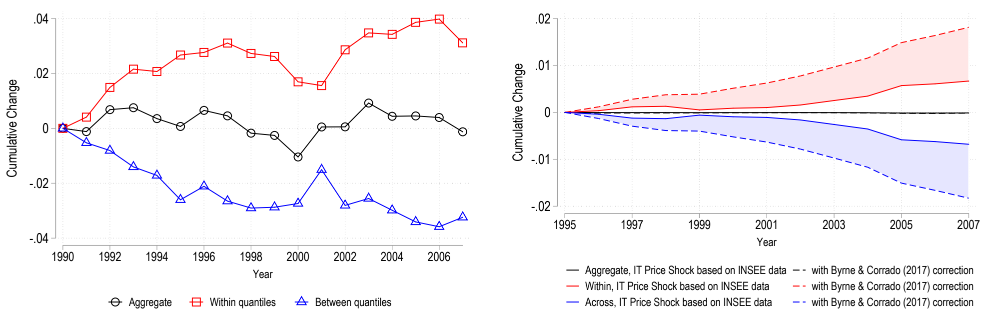
(a) Production Concentration in the Data (b) Response of Concentration to IT Shock



Note: Panel (a) presents the evolution of the sales-weighted averages (across 3-digits industries) of the cumulative change in concentration, measured as the share in total industry sales of the largest 1%, 5% , 1, 4, 10 or 20 firms. Panel (b) shows the cumulative changes in the shares of the largest 1% and 5% of firms predicted by the model (based on the calibrated dataset) in response to the two series for the relative IT prices over the 1995-2007 period.

Figure 4: Evolution of Labor Share in France: Data vs. Model Predictions, Benchmark

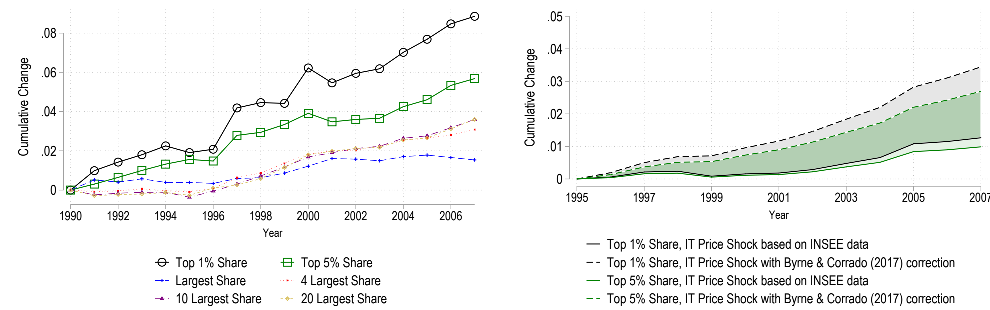
(a) Labor Share Decomposition (b) Response of Labor Share to IT Shock



Note: Note. Panel (a) presents the cumulative change in the aggregate labor share, as well as the decomposition of this change to within and across-firm components (at the level of 2-digit industries). Panel (b) shows the correpsonding responses predicted by the model (based on the calibrated dataset) to the two series for the relative IT prices over the 1995-2007 period.

Figure 3: Rise of Concentration in France: Data vs. Model Predictions, Alternative

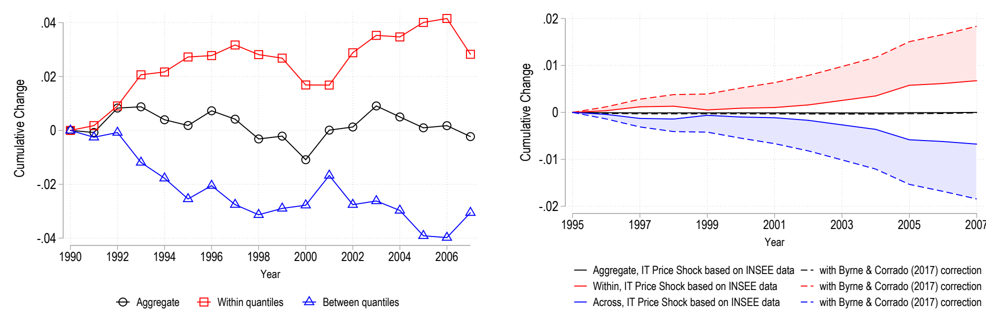
(a) Production Concentration in the Data (b) Response of Concentration to IT Shock



Note: Panel (a) presents the evolution of the sales-weighted averages (across 3-digits industries) of the cumulative change in concentration, measured as the share in total industry sales of the largest 1%, 5% , 1, 4, 10 or 20 firms. Panel (b) shows the cumulative changes in the shares of the largest 1% and 5% of firms predicted by the model (based on the calibrated dataset) in response to the two series for the relative IT prices over the 1995-2007 period.

Figure 4: Evolution of Labor Share in France: Data vs. Model Predictions, Alternative

(a) Labor Share Decomposition (b) Response of Labor Share to IT Shock

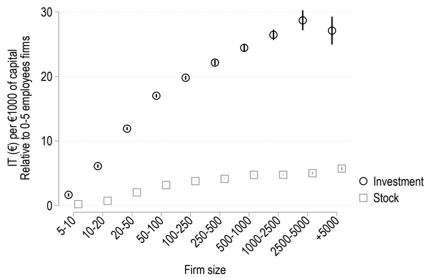


Note: Note. Panel (a) presents the cumulative change in the aggregate labor share, as well as the decomposition of this change to within and across-firm components (at the level of 2-digit industries). Panel (b) shows the correpsonding responses predicted by the model (based on the calibrated dataset) to the two series for the relative IT prices over the 1995-2007 period.

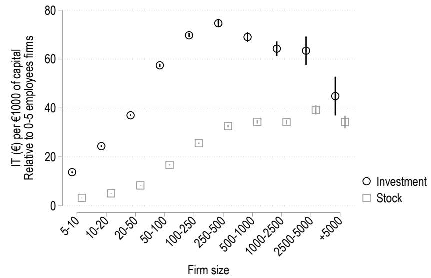
B Additional Details on Empirical Results

Figure 5: Cross-sectional Relationship Between IT and Firm Size, Benchmark

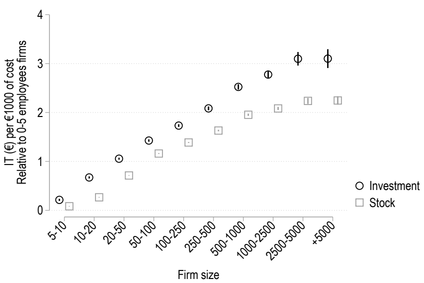
(a) Software per unit of capital



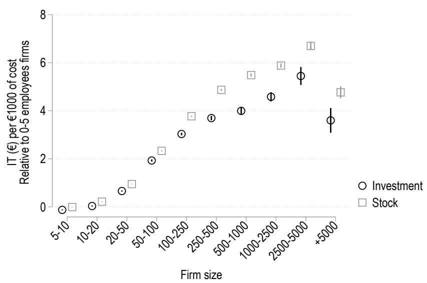
(b) Hardware per unit of capital



(c) Software per unit of costs



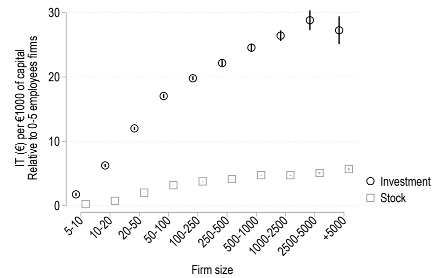
(d) Hardware per unit of costs



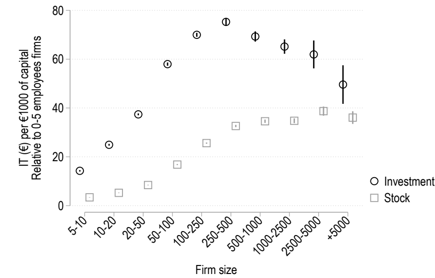
Note: This figure reports average IT investment and stock per €1000 of capital and cost by firm size class. In bottom panels, Investment and Stock stand for measures based on investment values and factor payment, respectively. Averages are conditional on a set of flexible fixed effects constructed from the interaction of 3-digit industry codes and time dummies, and a full set of cohorts fixed effect (pre 1980, 1980-1993, 1993-1995 ... 2005-2007) and normalized age fixed effects. In the case of software, sample is all firms that were sampled in EAE (that year for investment, at least once for capital). In the case of hardware, sample is all firms that reported hardware investment lower than 0.99 times total investment. The bands around the estimates show the 90% confidence intervals.

Figure 5: Cross-sectional Relationship Between IT and Firm Size, Alternative

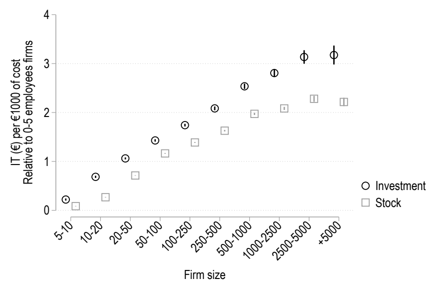
(a) Software per unit of capital



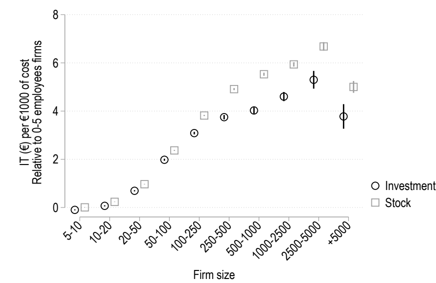
(b) Hardware per unit of capital



(c) Software per unit of costs



(d) Hardware per unit of costs



Note: This figure reports average IT investment and stock per €1000 of capital and cost by firm size class. In bottom panels, Investment and Stock stand for measures based on investment values and factor payment, respectively. Averages are conditional on a set of flexible fixed effects constructed from the interaction of 3-digit industry codes and time dummies, and a full set of cohorts fixed effect (pre 1980, 1980-1993, 1993-1995 ... 2005-2007) and normalized age fixed effects. In the case of software, sample is all firms that were sampled in EAE (that year for investment, at least once for capital). In the case of hardware, sample is all firms that reported hardware investment lower than 0.99 times total investment. The bands around the estimates show the 90% confidence intervals.

Table 5: Regressions of IT per Employee on Log Firm Size, by Bins of Employment, Benchmark

	IT per Employee									
	[1; 50[	[50; 100[	[100; 250[	[250; 1000[	≥ 1000	[1; 50[	[50; 100[	[100; 250[	[250; 1000[	≥ 1000
Panel 1: Software (Stock)										
Size (proxied by sales)	0.3964	0.5160	0.4490	0.4755	0.3768					
	(0.0057)	(0.0137)	(0.0141)	(0.0190)	(0.0396)					
Size (proxied by VA)						0.3306	0.5589	0.4845	0.5233	0.4041
						(0.0064)	(0.0168)	(0.0172)	(0.0219)	(0.0425)
Observations	393,470	94,433	67,577	31,031	6,154	393,527	94,455	67,585	31,038	6,154
R2	0.259	0.232	0.250	0.306	0.391	0.255	0.229	0.248	0.305	0.391
Panel 1: Hardware (Stock)										
Size (proxied by sales)	0.1685	1.0493	0.8140	0.5302	0.3255					
	(0.0009)	(0.0063)	(0.0061)	(0.0074)	(0.0137)					
Size (proxied by VA)						0.0688	0.9227	0.7437	0.5045	0.2933
						(0.0010)	(0.0078)	(0.0074)	(0.0087)	(0.0143)
Observations	2,645,249	137,207	95,862	41,973	8,236	2,645,384	137,244	95,889	41,994	8,236
R2	0.446	0.453	0.502	0.510	0.579	0.440	0.402	0.466	0.489	0.570

Note: In both panels the dependent variable is the logarithm of IT stock per employee. Standard errors are reported in brackets. In columns (1)-(5) and (6)-(10) we report results of regressions for firms in various bins of total number of employees: less than 50 employees, 50 to 100, ... up to more than 1000 employees. The independent variable is the logarithm of firm size either proxied by sales or value added. The time period is 1995-2007. In panel 1 the sample is all firms sampled by EAE, and in panel 2, the sample is BRN firms. All columns include a full set of 3-digit industry classification fixed effects interacted with year fixed effects and a full set of cohorts fixed effect (pre 1980, 1980-1993, 1993-1995 ... 2005-2007) and normalized age fixed effects. An elasticity of 0.3997 means that raising sales by a factor of 2 raises IT per employee by 39.97%.

Table 5: Regressions of IT per Employee on Log Firm Size, by Bins of Employment, Alternative

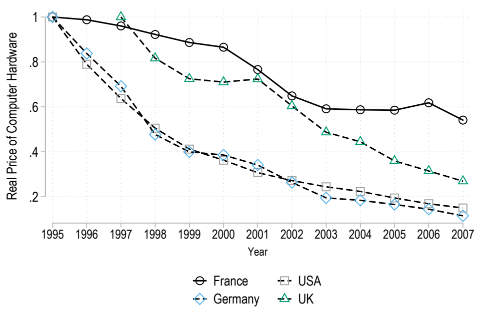
	IT per Employee									
	[1; 50[	[50; 100[	[100; 250[	[250; 1000[	≥ 1000	[1; 50[	[50; 100[	[100; 250[	[250; 1000[	≥ 1000
Panel 1: Software (Stock)										
Size (proxied by sales)	0.3999	0.5753	0.4786	0.4428	0.2336					
	(0.0056)	(0.0143)	(0.0152)	(0.0204)	(0.0451)					
Size (proxied by VA)						0.3199	0.5933	0.4947	0.4891	0.2333
						(0.0064)	(0.0174)	(0.0185)	(0.0235)	(0.0485)
Observations	404,458	96,879	69,683	32,157	6,569	404,528	96,907	69,692	32,166	6,569
R2	0.276	0.266	0.308	0.374	0.430	0.271	0.263	0.305	0.373	0.430
Panel 1: Hardware (Stock)										
Size (proxied by sales)	0.1689	1.0553	0.8159	0.5381	0.3073					
	(0.0009)	(0.0063)	(0.0062)	(0.0074)	(0.0137)					
Size (proxied by VA)						0.0687	0.9244	0.7549	0.5162	0.2667
						(0.0010)	(0.0077)	(0.0074)	(0.0087)	(0.0145)
Observations	2,680,641	138,252	96,775	42,660	8,545	2,680,880	138,290	96,808	42,681	8,545
R2	0.445	0.455	0.502	0.512	0.562	0.440	0.405	0.467	0.492	0.552

Note: In both panels the dependent variable is the logarithm of IT stock per employee. Standard errors are reported in brackets. In columns (1)-(5) and (6)-(10) we report results of regressions for firms in various bins of total number of employees: less than 50 employees, 50 to 100, ... up to more than 1000 employees. The independent variable is the logarithm of firm size either proxied by sales or value added. The time period is 1995-2007. In panel 1 the sample is all firms sampled by EAE, and in panel 2, the sample is BRN firms. All columns include a full set of 3-digit industry classification fixed effects interacted with year fixed effects and a full set of cohorts fixed effect (pre 1980, 1980-1993, 1993-1995 ... 2005-2007) and normalized age fixed effects. An elasticity of 0.3997 means that raising sales by a factor of 2 raises IT per employee by 39.97%.

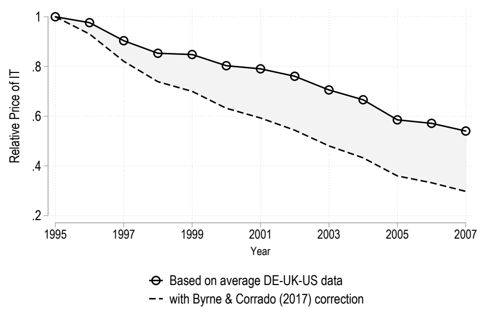
OA.1 Data Appendix

Figure OA.1: Alternative Computer Price, Benchmark

(a) Real Computer Price in France and Other Countries



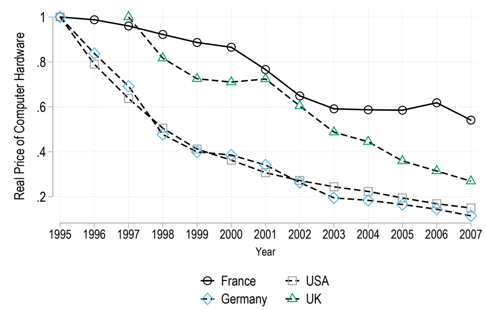
(b) Alternative Fall in Relative IT Prices



Note: Panel (a) presents series of computer prices minus value-added price for the market economy in four countries that used different methods to correct for quality improvements (Sources: EU KLEMS). Panel (b) presents the evolution of an alternative relative price of IT for France, constructed based on the INSEE National Accounts data as in the main text but using the average price of Computers in Germany, the UK and the US; and that constructed by incorporating the same correction based on the estimates of Byrne and Corrado (2017) for the bias in the official prices of IT investment goods in the US data.

Figure OA.1: Alternative Computer Price, Alternative

(a) Real Computer Price in France and Other Countries, Alternative



(b) Alternative Fall in Relative IT Prices

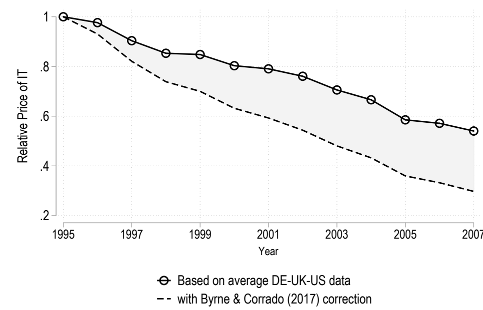


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Table OA.1: Summary Statistics, Benchmark

	Source	All firms Obs. (Nb)	All firms Mean	All firms Median	All firms Sd	Manufacturing firms Obs. (Nb)	Manufacturing firms Mean	Manufacturing firms Median	Manufacturing firms Sd
Sales	BRN + RSI	15,202,793	2,498.8	265	85,057.3	2,422,365	4,171.0	316.9	60,560.3
Value-Added	BRN + RSI	15,202,793	708.3	106	33,071.6	2,422,365	1,271.8	147.1	25,846.6
Number of Employees	BRN + RSI	15,202,793	13.8	3	480.7	2,422,365	23.3	4	177.0
Wage Bill	BRN + RSI	15,202,793	472.4	74	18,404.6	2,422,365	815.2	109	8,105.5
Labor Share (%)	BRN + RSI	15,202,793	86.2	73.0	813.6	2,422,365	85.2	73.5	1,708.5
Total Investment	BRN	6,336,678	140.2	4.7	9,746.9	1,014,025	269.1	12	4,038.0
Total Capital Stock	BRN	6,336,678	1,205.9	88.6	92,054.5	1,014,025	2,616.0	218.3	30,711.6
Total Cost	BRN	6,336,677	888.2	180.3	33,090.3	1,014,025	1,558.2	303.8	12,468.7
IT Measures									
Software Investment	EAE	2,511,960	5.7	0	520.1	390,632	14.5	0	287.3
Software Stock	EAE	2,511,960	15.4	0	1,197.5	390,632	40.3	0.7	712.8
Hardware Investment	BRN	6,336,678	5.9	0	399.9	1,014,025	9.0	0	170.9
Hardware Stock	BRN	6,336,678	24.0	0	1,832.4	1,014,025	44.8	0	656.8
IT per Worker									
Software Investment	EAE	2,511,960	27.1	0	165.2	390,632	66.2	0	225.8
Software Stock	EAE	2,511,960	80.9	0	3,165.3	390,632	218.3	20.1	7,726.5
Hardware Investment	BRN	6,336,678	171.7	0	786.3	1,014,025	111.0	0	475.5
Hardware Stock	BRN	6,336,678	472.2	0	2,412.0	1,014,025	392.8	0	1,222.7
IT per Unit of Capital									
Software Investment	EAE	2,046,011	21.5	0	1,184.9	362,847	28.8	0	796.0
Software Stock	EAE	2,359,661	3.9	0	28.6	381,562	6.0	0.5	26.8
Hardware Investment	BRN	4,498,705	109.0	0	1,748.3	791,217	68.8	0	1,411.3
Hardware Stock	BRN	5,716,575	38.7	0	127.0	943,285	18.3	0.2	70.5
IT per Unit of Cost									
Software Investment	EAE	2,511,953	0.6	0	4.1	390,632	1.6	0	5.4
Software Stock	EAE	2,511,960	0.6	0	2.9	390,632	1.6	0.2	4.3
Hardware Investment	BRN	6,336,632	3.7	0	28.1	1,014,019	2.5	0	15.6
Hardware Stock	BRN	6,336,677	2.3	0	7.8	1,014,025	1.6	0	4.5

Note: The units for all variables are thousand euros except for those involving intensity, share, or numbers. The units for the IT intensity of labor, capital, and cost are euros per worker, euros per thousand euros of capital, and euros per thousand euros of cost, respectively. Labor share, in percentage points, is defined as the sum of wage bill and payroll taxes divided by value-added. Stock measures are built using the Perpetual Inventory Method (PIM), imputing zero investment for missing data. The table reports hardware and capital inputs for all firms included at least once in the BRN files, and software inputs for all firms surveyed at least once by EAE. Section OA.2.4 describes the data sources for each variable. The period is 1990-2007 for BRN + RSI data, 1995-2007 for BRN and EAE data. For the IT intensity of capital, the number of non missing observations is lower because of the higher occurrence of zeros in the denominator.

Table OA.1: Summary Statistics, Alternative

	Source	All firms Obs. (Nb)	All firms Mean	All firms Median	All firms Sd	Manufacturing firms Obs. (Nb)	Manufacturing firms Mean	Manufacturing firms Median	Manufacturing firms Sd
Sales	BRN + RSI	15,459,261	2,534.3	266	85,495.8	2,554,512	4,437.9	319.5	79,630.4
Value-Added	BRN + RSI	15,459,261	717.1	107	33,014.9	2,554,512	1,339.6	147.1	29,744.9
Number of Employees	BRN + RSI	15,459,261	13.9	3	479.9	2,554,512	23.6	4	182.8
Wage Bill	BRN + RSI	15,459,261	478.2	74.2	18,451.8	2,554,512	836.3	108.4	8,482.1
Labor Share (%)	BRN + RSI	15,459,261	86.2	72.9	809.6	2,554,512	85.0	73.3	1,690.0
Total Investment	BRN	6,464,255	141.6	4.7	9,738.9	1,075,050	273.1	11.9	4,196.6
Total Capital Stock	BRN	6,464,255	1,214.6	88.9	91,598.6	1,075,050	2,650.0	215.3	30,679.7
Total Cost	BRN	6,464,254	894.4	181.1	33,143.7	1,075,050	1,588.6	298.8	12,937.7
IT Measures									
Software Investment	EAE	2,569,390	5.8	0	515.3	405,920	15.4	0	294.3
Software Stock	EAE	2,569,390	15.6	0	1,188.6	405,920	43.0	0.8	726.9
Hardware Investment	BRN	6,464,255	5.9	0	399.2	1,075,050	9.4	0	175.7
Hardware Stock	BRN	6,464,255	24.4	0	1,819.0	1,075,050	47.1	0	675.9
IT per Worker									
Software Investment	EAE	2,569,390	27.6	0	169.6	405,920	67.7	0	230.5
Software Stock	EAE	2,569,390	83.8	0	3,139.1	405,920	222.3	22.1	7,559.8
Hardware Investment	BRN	6,464,255	172.9	0	795.7	1,075,050	113.8	0	487.0
Hardware Stock	BRN	6,464,255	478.7	0	2,516.4	1,075,050	405.2	0	1,262.2
IT per Unit of Capital									
Software Investment	EAE	2,092,313	21.8	0	1,178.7	377,548	29.3	0	762.9
Software Stock	EAE	2,413,294	4.0	0	29.2	396,757	6.0	0.6	26.1
Hardware Investment	BRN	4,584,180	108.6	0	991.0	838,217	70.3	0	1,374.2
Hardware Stock	BRN	5,826,631	38.9	0	127.4	1,000,118	18.7	0.2	71.4
IT per Unit of Cost									
Software Investment	EAE	2,569,383	0.7	0	4.2	405,920	1.6	0	5.5
Software Stock	EAE	2,569,390	0.6	0	3.1	405,920	1.6	0.2	4.3
Hardware Investment	BRN	6,464,210	3.7	0	27.7	1,075,044	2.5	0	15.5
Hardware Stock	BRN	6,464,254	2.3	0	7.8	1,075,050	1.7	0	4.6

Note: The units for all variables are thousand euros except for those involving intensity, share, or numbers. The units for the IT intensity of labor, capital, and cost are euros per worker, euros per thousand euros of capital, and euros per thousand euros of cost, respectively. Labor share, in percentage points, is defined as the sum of wage bill and payroll taxes divided by value-added. Stock measures are built using the Perpetual Inventory Method (PIM), imputing zero investment for missing data. The table reports hardware and capital inputs for all firms included at least once in the BRN files, and software inputs for all firms surveyed at least once by EAE. Section OA.2.4 describes the data sources for each variable. The period is 1990-2007 for BRN + RSI data, 1995-2007 for BRN and EAE data. For the IT intensity of capital, the number of non missing observations is lower because of the higher occurrence of zeros in the denominator.

Table OA.2: Software Investment Summary Statistics (1996), Benchmark

1996	Number of Firms				Average values		Median values
	All	EAE	No software investment	Some software investment	EAE	Some software investment	Some software investment
0-5	214,156	10,970	10,935	35	0.01	2.53	2.13
5-10	135,664	13,970	13,687	283	0.09	4.20	1.83
10-20	58,170	12,003	11,121	882	0.50	6.76	2.74
20-50	48,896	33,614	27,140	6,474	1.61	8.35	3.35
50-100	11,392	9,746	6,662	3,084	4.61	14.58	6.02
100-250	7,200	6,361	3,741	2,620	11.87	28.82	10.98
250-500	2,173	2,006	1,000	1,006	31.22	62.25	31.79
500-1000	938	897	373	524	92.35	158.08	70.81
1000-2500	450	432	164	268	237.73	383.21	160.38
2500-5000	119	112	42	70	517.22	827.55	401.09
+5000	55	51	18	33	5741.85	8873.76	759.20

Note: The first column denote the class size in terms of BRN employment. Columns (2)-(5) count the number of firms for each of the four samples, in each class size : all firms in 1996, firms sampled in EAE in 1996, of which firms that declared zero or missing software investment, and firms that declared positive software investment. Columns (6)-(7) display average software investment for all firms in EAE in 1996 and those that declared positive investment. Column (8) displays median software investment for firms that declared positive software investment.

Table OA.2: Software Investment Summary Statistics (1996), Alternative

1996	Number of Firms				Average values		Median values
	All	EAE	No software investment	Some software investment	EAE	Some software investment	Some software investment
0-5	216,760	11,139	11,102	37	0.01	2.58	2.13
5-10	137,699	14,253	13,943	310	0.09	4.31	1.98
10-20	59,139	12,262	11,351	911	0.50	6.73	2.74
20-50	49,844	34,232	27,598	6,634	1.63	8.41	3.35
50-100	11,625	9,944	6,783	3,161	4.65	14.63	6.10
100-250	7,370	6,507	3,841	2,666	11.94	29.15	11.05
250-500	2,226	2,057	1,027	1,030	31.51	62.92	31.63
500-1000	971	928	388	540	91.44	157.14	70.81
1000-2500	467	448	170	278	235.48	379.49	160.38
2500-5000	122	116	43	73	505.32	802.98	368.47
+5000	59	55	20	35	5606.18	8809.72	796.24

Note: The first column denote the class size in terms of BRN employment. Columns (2)-(5) count the number of firms for each of the four samples, in each class size : all firms in 1996, firms sampled in EAE in 1996, of which firms that declared zero or missing software investment, and firms that declared positive software investment. Columns (6)-(7) display average software investment for all firms in EAE in 1996 and those that declared positive investment. Column (8) displays median software investment for firms that declared positive software investment.

OA.2 Details on the Micro-Level Reduced-Form Facts

Table OA.3: Regressions of Log Relative IT Demand on Log Firm Size, Benchmark

	IT per Unit of Labor				IT per Unit of Capital				IT per Unit of Cost	
	Workers	Workers	Wage Bill	Wage Bill	Total	Total	Tangible	Tangible	Costs	Costs
Panel 1: Software (Stock)										
Size (proxied by sales)	0.3688		0.3151		0.2807		0.2860		0.3033	
	(0.0031)		(0.0030)		(0.0032)		(0.0032)		(0.0030)	
Size (proxied by VA)		0.3499		0.2974		0.2935		0.3005		0.2876
		(0.0033)		(0.0033)		(0.0034)		(0.0034)		(0.0032)
Observations	594,009	594,104	593,995	594,095	547,292	547,355	546,410	546,472	594,079	594,182
R2	0.244	0.240	0.233	0.229	0.239	0.239	0.240	0.239	0.236	0.233
Panel 1: Software (Investment)										
Size (proxied by sales)	20.2336		0.4983		4.3970		5.2124		0.4245	
	(0.1046)		(0.0028)		(0.0272)		(0.0341)		(0.0024)	
Size (proxied by VA)		20.8305		0.5142		4.7130		5.6050		0.4368
		(0.1105)		(0.0030)		(0.0287)		(0.0360)		(0.0026)
Observations	1,177,293	1,177,490	1,177,325	1,177,526	1,158,549	1,158,739	1,147,751	1,147,910	1,177,950	1,178,148
R2	0.090	0.089	0.084	0.082	0.081	0.082	0.075	0.076	0.082	0.081
Panel 1: Hardware (Stock)										
Size (proxied by sales)	0.2664		0.2062		0.2134		0.2256		0.2025	
	(0.0007)		(0.0007)		(0.0008)		(0.0008)		(0.0007)	
Size (proxied by VA)		0.2027		0.1321		0.1710		0.1865		0.1312
		(0.0008)		(0.0008)		(0.0009)		(0.0009)		(0.0008)
Observations	2,929,990	2,930,210	2,929,984	2,930,381	2,842,300	2,842,532	2,843,134	2,843,281	2,931,093	2,931,455
R2	0.423	0.411	0.387	0.376	0.422	0.417	0.454	0.448	0.350	0.339
Panel 1: Hardware (Investment)										
Size (proxied by sales)	41.1108		0.8824		17.2867		19.8968		0.7492	
	(0.1803)		(0.0051)		(0.0562)		(0.0699)		(0.0037)	
Size (proxied by VA)		32.3492		0.6012		15.8463		18.3580		0.5454
		(0.1854)		(0.0052)		(0.0578)		(0.0719)		(0.0038)
Observations	4,451,987	4,452,704	4,450,990	4,451,843	4,478,768	4,479,477	4,409,937	4,410,454	4,456,254	4,457,018
R2	0.164	0.160	0.138	0.135	0.185	0.182	0.240	0.237	0.147	0.143

Note: In panels 2 and 4, the dependent variable is IT investment per unit of labor, capital, and cost and in panels 1 and 3 it is the logarithm of IT stock per unit of labor, capital and cost. Standard errors are reported in brackets. In columns (1)-(4) we report results of IT per unit of labor, in columns (5)-(8) we report results for IT per unit of capital, and in columns (9) and (10) we report results of IT per unit of cost. The independent variable is the logarithm of firm size either proxied by sales or value added. The time period is 1995-2007. In panels 1 and 2 the sample is all firms sampled by EAE, and in panels 3 and 4, the sample is BRN firms. All columns include a full set of 3-digit industry classification fixed effects interacted with year fixed effects and a full set of cohorts fixed effect (pre 1980, 1980-1993, 1993-1995 ... 2005-2007) and normalized age fixed effects. For investment intensities semi-elasticities, units matter for interpretation. The units for the IT demand per unit of labor, capital, and cost are euros per worker, euros per thousand euros of capital, and euros per thousand euros of cost, respectively. Imputed values of the "investment" measures are dropped from the analysis. A semi-elasticity of 20.5 of software investment per worker to sales means that raising sales by a factor of 2 raises software per worker by $20.5 \log 2 = 14$ euros. An elasticity of 0.365 of sofware stock per worker to sales means that raising sales by a factor of 2 raises software stock per worker by 36.5%.

Table OA.3: Regressions of Log Relative IT Demand on Log Firm Size, Alternative

	IT per Unit of Labor				IT per Unit of Capital				IT per Unit of Cost	
	Workers	Workers	Wage Bill	Wage Bill	Total	Total	Tangible	Tangible	Costs	Costs
Panel 1: Software (Stock)										
Size (proxied by sales)	0.3728		0.3190		0.2881		0.2927		0.3074	
	(0.0031)		(0.0031)		(0.0032)		(0.0032)		(0.0031)	
Size (proxied by VA)		0.3480		0.2954		0.2945		0.3009		0.2854
		(0.0033)		(0.0033)		(0.0034)		(0.0034)		(0.0033)
Observations	611,017	611,132	610,977	611,095	563,852	563,934	562,904	562,986	611,053	611,174
R2	0.268	0.264	0.255	0.252	0.252	0.251	0.252	0.251	0.258	0.255
Panel 1: Software (Investment)										
Size (proxied by sales)	20.5097		0.5013		4.4036		5.2412		0.4278	
	(0.1057)		(0.0028)		(0.0273)		(0.0342)		(0.0024)	
Size (proxied by VA)		21.0529		0.5160		4.7111		5.6174		0.4392
		(0.1118)		(0.0030)		(0.0289)		(0.0361)		(0.0026)
Observations	1,190,035	1,190,245	1,190,025	1,190,238	1,171,205	1,171,407	1,160,167	1,160,337	1,190,665	1,190,876
R2	0.091	0.090	0.084	0.083	0.083	0.083	0.076	0.077	0.083	0.082
Panel 1: Hardware (Stock)										
Size (proxied by sales)	0.2655		0.2056		0.2121		0.2236		0.2023	
	(0.0007)		(0.0007)		(0.0008)		(0.0008)		(0.0007)	
Size (proxied by VA)		0.2016		0.1312		0.1684		0.1830		0.1306
		(0.0008)		(0.0008)		(0.0009)		(0.0009)		(0.0008)
Observations	2,968,221	2,968,545	2,968,486	2,968,982	2,880,420	2,880,756	2,882,163	2,882,429	2,969,420	2,969,889
R2	0.424	0.412	0.386	0.376	0.423	0.418	0.454	0.448	0.350	0.339
Panel 1: Hardware (Investment)										
Size (proxied by sales)	41.8449		0.9007		17.4527		20.1336		0.7663	
	(0.1794)		(0.0050)		(0.0562)		(0.0700)		(0.0036)	
Size (proxied by VA)		33.1486		0.6220		16.0139		18.6010		0.5639
		(0.1848)		(0.0052)		(0.0579)		(0.0721)		(0.0038)
Observations	4,466,831	4,467,628	4,466,380	4,467,298	4,492,865	4,493,648	4,423,162	4,423,745	4,470,762	4,471,602
R2	0.158	0.154	0.131	0.128	0.184	0.181	0.237	0.235	0.142	0.138

Note: In panels 2 and 4, the dependent variable is IT investment per unit of labor, capital, and cost and in panels 1 and 3 it is the logarithm of IT stock per unit of labor, capital and cost. Standard errors are reported in brackets. In columns (1)-(4) we report results of IT per unit of labor, in columns (5)-(8) we report results for IT per unit of capital, and in columns (9) and (10) we report results of IT per unit of cost. The independent variable is the logarithm of firm size either proxied by sales or value added. The time period is 1995-2007. In panels 1 and 2 the sample is all firms sampled by EAE, and in panels 3 and 4, the sample is BRN firms. All columns include a full set of 3-digit industry classification fixed effects interacted with year fixed effects and a full set of cohorts fixed effect (pre 1980, 1980-1993, 1993-1995 ... 2005-2007) and normalized age fixed effects. For investment intensities semi-elasticities, units matter for interpretation. The units for the IT demand per unit of labor, capital, and cost are euros per worker, euros per thousand euros of capital, and euros per thousand euros of cost, respectively. Imputed values of the "investment" measures are dropped from the analysis. A semi-elasticity of 20.5 of software investment per worker to sales means that raising sales by a factor of 2 raises software per worker by $20.5 \log 2 = 14$ euros. An elasticity of 0.365 of sofware stock per worker to sales means that raising sales by a factor of 2 raises software stock per worker by 36.5%.

Table OA.4: Regressions of Log Relative IT Demand on Alternative Measures of Firm Size, Benchmark

	IT per Unit of Labor				IT per Unit of Capital				IT per Unit of Cost	
	Workers	Workers	Wage Bill	Wage Bill	Total	Total	Tangible	Tangible	Costs	Costs
Panel 1: Software (Stock)										
Number of plants	0.0015		0.0015		0.0014		0.0016		0.0013	
	(0.0002)		(0.0002)		(0.0002)		(0.0002)		(0.0002)	
Number of occupational layers		0.2634		0.2242		0.2567		0.2604		0.2262
		(0.0047)		(0.0047)		(0.0049)		(0.0049)		(0.0046)
Observations	580,662	580,662	580,811	580,811	535,128	535,128	534,275	534,275	580,850	580,850
R2	0.226	0.230	0.219	0.222	0.228	0.232	0.228	0.232	0.223	0.226
Number of destination countries	0.0277		0.0244		0.0225		0.0231		0.0239	
	(0.0004)		(0.0004)		(0.0004)		(0.0004)		(0.0004)	
Number of products		0.0066		0.0060		0.0055		0.0057		0.0059
		(0.0002)		(0.0002)		(0.0002)		(0.0002)		(0.0002)
Observations	287,740	287,740	288,564	288,564	270,172	270,172	269,947	269,947	288,886	288,886
R2	0.201	0.193	0.194	0.187	0.191	0.185	0.192	0.186	0.197	0.191
Panel 1: Hardware (Stock)										
Number of plants	0.0040		0.0040		0.0036		0.0040		0.0038	
	(0.0001)		(0.0001)		(0.0001)		(0.0001)		(0.0001)	
Number of occupational layers		0.1012		0.0721		0.1120		0.1227		0.0757
		(0.0009)		(0.0009)		(0.0010)		(0.0010)		(0.0009)
Observations	2,811,644	2,811,644	2,813,268	2,813,268	2,732,468	2,732,468	2,733,730	2,733,730	2,813,897	2,813,897
R2	0.396	0.398	0.368	0.369	0.407	0.409	0.437	0.440	0.330	0.331
Number of destination countries	0.0340		0.0302		0.0257		0.0268		0.0294	
	(0.0002)		(0.0002)		(0.0002)		(0.0002)		(0.0002)	
Number of products		0.0084		0.0077		0.0067		0.0069		0.0075
		(0.0001)		(0.0001)		(0.0001)		(0.0001)		(0.0001)
Observations	570,042	570,042	572,530	572,530	562,342	562,342	563,260	563,260	572,502	572,502
R2	0.285	0.264	0.255	0.238	0.314	0.304	0.334	0.324	0.224	0.207

Note: In all panels the dependent variable is the logarithm of IT stock per unit of labor, capital, and cost. Standard errors are reported in brackets. In columns (1)-(4) we report results of IT per unit of labor, in columns (5)-(8) we report results for IT per unit of capital, and in columns (9) and (10) we report results of IT per unit of cost. The time period is 1995-2007. In panel 1 the sample is all firms sampled by EAE, and in panel 2 the sample is BRN firms. All columns include a full set of 3-digit industry classification fixed effects interacted with year fixed effects and a full set of cohorts fixed effect (pre 1980, 1980-1993, 1993-1995 ... 2005-2007) and normalized age fixed effects. A semi-elasticity of 0.0276 of software stock per worker to the number of destination countries means that exporting to one new country raises software stock per worker by 2.76%.

Table OA.4: Regressions of Log Relative IT Demand on Alternative Measures of Firm Size, Alternative

	IT per Unit of Labor				IT per Unit of Capital				IT per Unit of Cost	
	Workers	Workers	Wage Bill	Wage Bill	Total	Total	Tangible	Tangible	Costs	Costs
Panel 1: Software (Stock)										
Number of plants	0.0020		0.0018		0.0018		0.0019		0.0017	
	(0.0002)		(0.0002)		(0.0002)		(0.0002)		(0.0002)	
Number of occupational layers		0.2613		0.2217		0.2543		0.2587		0.2234
		(0.0047)		(0.0047)		(0.0049)		(0.0049)		(0.0047)
Observations	597,443	597,443	597,564	597,564	551,467	551,467	550,553	550,553	597,591	597,591
R2	0.251	0.254	0.242	0.245	0.241	0.244	0.241	0.245	0.246	0.249
Number of destination countries	0.0272		0.0238		0.0220		0.0227		0.0233	
	(0.0004)		(0.0004)		(0.0004)		(0.0004)		(0.0004)	
Number of products		0.0069		0.0062		0.0058		0.0060		0.0061
		(0.0002)		(0.0002)		(0.0002)		(0.0002)		(0.0002)
Observations	292,533	292,533	293,253	293,253	274,936	274,936	274,650	274,650	293,607	293,607
R2	0.220	0.213	0.213	0.208	0.209	0.204	0.210	0.205	0.217	0.212
Panel 1: Hardware (Stock)										
Number of plants	0.0040		0.0040		0.0036		0.0040		0.0038	
	(0.0001)		(0.0001)		(0.0001)		(0.0001)		(0.0001)	
Number of occupational layers		0.1011		0.0721		0.1119		0.1217		0.0760
		(0.0009)		(0.0009)		(0.0010)		(0.0010)		(0.0009)
Observations	2,849,372	2,849,372	2,851,297	2,851,297	2,770,247	2,770,247	2,772,312	2,772,312	2,851,753	2,851,753
R2	0.397	0.399	0.368	0.369	0.408	0.410	0.437	0.440	0.330	0.331
Number of destination countries	0.0338		0.0300		0.0256		0.0266		0.0292	
	(0.0002)		(0.0002)		(0.0002)		(0.0002)		(0.0002)	
Number of products		0.0083		0.0076		0.0066		0.0068		0.0075
		(0.0001)		(0.0001)		(0.0001)		(0.0001)		(0.0001)
Observations	574,969	574,969	577,485	577,485	567,628	567,628	568,604	568,604	577,541	577,541
R2	0.286	0.266	0.256	0.239	0.315	0.305	0.335	0.325	0.225	0.208

Note: In all panels the dependent variable is the logarithm of IT stock per unit of labor, capital, and cost. Standard errors are reported in brackets. In columns (1)-(4) we report results of IT per unit of labor, in columns (5)-(8) we report results for IT per unit of capital, and in columns (9) and (10) we report results of IT per unit of cost. The time period is 1995-2007. In panel 1 the sample is all firms sampled by EAE, and in panel 2 the sample is BRN firms. All columns include a full set of 3-digit industry classification fixed effects interacted with year fixed effects and a full set of cohorts fixed effect (pre 1980, 1980-1993, 1993-1995 ... 2005-2007) and normalized age fixed effects. A semi-elasticity of 0.0276 of software stock per worker to the number of destination countries means that exporting to one new country raises software stock per worker by 2.76%.

Table OA.5: Regressions of Relative IT Demand on Log Firm Size (Within Firm), Benchmark

	IT per Unit of Labor				IT per Unit of Capital				IT per Unit of Cost	
	Workers	Workers	Wage Bill	Wage Bill	Total	Total	Tangible	Tangible	Costs	Costs
Panel 1: Software (Stock)										
Size (proxied by sales)	0.2138		0.1509		0.3442		0.3594		0.1724	
	(0.0328)		(0.0330)		(0.0338)		(0.0339)		(0.0328)	
Size (proxied by VA)		0.2224		0.1472		0.3395		0.3461		0.1746
		(0.0289)		(0.0290)		(0.0298)		(0.0298)		(0.0290)
Observations	236,510	236,617	236,379	236,434	224,344	224,615	224,730	225,052	236,416	236,461
R2	0.835	0.830	0.830	0.826	0.829	0.824	0.829	0.825	0.831	0.826
Panel 1: Hardware (Stock)										
Size (proxied by sales)	0.2681		0.1743		0.3823		0.3874		0.1932	
	(0.0097)		(0.0098)		(0.0101)		(0.0102)		(0.0096)	
Size (proxied by VA)		0.1520		0.0506		0.2564		0.2597		0.0716
		(0.0082)		(0.0082)		(0.0085)		(0.0085)		(0.0081)
Observations	249,933	250,935	250,921	252,029	246,038	247,031	245,222	246,259	250,436	251,530
R2	0.867	0.866	0.843	0.843	0.905	0.905	0.915	0.915	0.845	0.846

Note: The dependent variable is the logarithm of IT stock per unit of labor, capital, and cost. Standard errors are reported in brackets. In columns (1)-(4) we report results of IT per unit of labor, in columns (5)-(8) we report results for IT per unit of capital, and in columns (9) and (10) we report results of IT per unit of cost. The independent variable is the logarithm of firm size either proxied by sales or value added. The time period is 1995-2007. In panel 1 the sample is all firms sampled by EAE, and in panel 2, the sample is BRN firms. All columns include a full set of firm fixed effects, and 3-digit industry classification fixed effects interacted with year fixed effects. An elasticity of 0.2042 of sofware stock per worker to sales means that raising sales by a factor of 2 raises software stock per worker by 20.42%.

Table OA.5: Regressions of Relative IT Demand on Log Firm Size (Within Firm), Alternative

	IT per Unit of Labor				IT per Unit of Capital				IT per Unit of Cost	
	Workers	Workers	Wage Bill	Wage Bill	Total	Total	Tangible	Tangible	Costs	Costs
Panel 1: Software (Stock)										
Size (proxied by sales)	0.2308		0.1652		0.3281		0.3389		0.1774	
	(0.0334)		(0.0335)		(0.0340)		(0.0341)		(0.0333)	
Size (proxied by VA)		0.2224		0.1495		0.3302		0.3380		0.1716
		(0.0294)		(0.0295)		(0.0300)		(0.0300)		(0.0293)
Observations	245,747	245,768	245,529	245,465	233,216	233,435	233,572	233,889	245,539	245,470
R2	0.835	0.831	0.830	0.826	0.828	0.823	0.828	0.823	0.831	0.827
Panel 1: Hardware (Stock)										
Size (proxied by sales)	0.2551		0.1610		0.3706		0.3766		0.1827	
	(0.0095)		(0.0095)		(0.0099)		(0.0100)		(0.0094)	
Size (proxied by VA)		0.1462		0.0435		0.2491		0.2528		0.0664
		(0.0080)		(0.0080)		(0.0083)		(0.0083)		(0.0079)
Observations	257,162	258,173	258,191	259,335	253,279	254,272	252,548	253,567	257,612	258,755
R2	0.867	0.867	0.845	0.844	0.906	0.906	0.916	0.916	0.846	0.847

Note: The dependent variable is the logarithm of IT stock per unit of labor, capital, and cost. Standard errors are reported in brackets. In columns (1)-(4) we report results of IT per unit of labor, in columns (5)-(8) we report results for IT per unit of capital, and in columns (9) and (10) we report results of IT per unit of cost. The independent variable is the logarithm of firm size either proxied by sales or value added. The time period is 1995-2007. In panel 1 the sample is all firms sampled by EAE, and in panel 2, the sample is BRN firms. All columns include a full set of firm fixed effects, and 3-digit industry classification fixed effects interacted with year fixed effects. An elasticity of 0.2042 of sofware stock per worker to sales means that raising sales by a factor of 2 raises software stock per worker by 20.42%.

Table OA.6: Reduced-Form Identification of the Size Elasticity of Relative IT Demand, Benchmark

	IT per Unit of Labor				IT per Unit of Capital				IT per Unit of Cost	
	Workers	Workers	Wage Bill	Wage Bill	Total	Total	Tangible	Tangible	Costs	Costs
Panel 1: Software (Stock)										
Size (proxied by sales)	0.5623		0.3551		0.4342		0.4988		0.5844	
	(0.3752)		(0.3783)		(0.3721)		(0.3823)		(0.3661)	
Size (proxied by VA)		0.9254		0.4466		0.8518		0.9496		0.7322
		(0.5223)		(0.4999)		(0.5120)		(0.5266)		(0.4888)
Observations	105,113	103,973	105,369	104,230	100,718	99,590	101,057	99,937	105,511	104,352
First stage F-stat	222.5	112.0	221.4	117.6	205.3	109.2	203.5	107.3	224.2	118.8
Panel 1: Hardware (Stock)										
Size (proxied by sales)	0.6770		0.4060		0.5344		0.4867		0.0065	
	(0.1354)		(0.1297)		(0.1308)		(0.1275)		(0.1210)	
Size (proxied by VA)		0.9577		0.4632		0.7937		0.7004		-0.0104
		(0.1795)		(0.1837)		(0.1782)		(0.1783)		(0.1684)
Observations	98,673	97,224	99,352	98,497	99,414	98,567	99,571	98,719	99,304	98,468
First stage F-stat	260.5	100.8	267.4	103.3	257.1	115.9	264.1	89.5	270.8	110.3

Note: The dependent variable is the logarithm of IT stock per unit of labor, capital, and cost. Standard errors are reported in brackets. In columns (1)-(4) we report results of IT per unit of labor, in columns (5)-(8) we report results for IT per unit of capital, and in columns (9) and (10) we report results of IT per unit of cost. The independent variable is the logarithm of firm size either proxied by sales or value added, instrumented by product demand shocks. The time period is 1997-2007. In panel 1 the sample is all exporting firms sampled by EAE, and in panel 3, the sample is exporting BRN firms. All columns include a full set of 3-digit industry classification fixed effects interacted with year fixed effects. An elasticity of 0.5656 of sofware stock per worker to sales means that raising sales by a factor of 2 raises software stock per worker by 56.56%. Observations are weighted by each firm's share of export in its total sales in 1995-1996.

Table OA.6: Reduced-Form Identification of the Size Elasticity of Relative IT Demand, Alternative

	IT per Unit of Labor				IT per Unit of Capital				IT per Unit of Cost	
	Workers	Workers	Wage Bill	Wage Bill	Total	Total	Tangible	Tangible	Costs	Costs
Panel 1: Software (Stock)										
Size (proxied by sales)	0.6521		0.2162		0.5630		0.6154		0.5568	
	(0.3896)		(0.3882)		(0.4028)		(0.3924)		(0.3823)	
Size (proxied by VA)		0.7612		0.3092		0.9993		0.9837		0.6833
		(0.5097)		(0.4970)		(0.5428)		(0.5310)		(0.4845)
Observations	107,489	106,498	107,762	106,763	103,028	102,085	103,395	102,439	107,870	106,873
First stage F-stat	198.8	118.6	202.5	124.3	190.1	111.9	192.3	112.9	200.9	126.4
Panel 1: Hardware (Stock)										
Size (proxied by sales)	0.7300		0.4155		0.5429		0.4663		0.0400	
	(0.1378)		(0.1313)		(0.1366)		(0.1350)		(0.1238)	
Size (proxied by VA)		1.0522		0.4703		0.8469		0.7248		0.0157
		(0.1819)		(0.1679)		(0.1717)		(0.1711)		(0.1603)
Observations	101,273	99,713	101,926	101,141	101,980	101,194	102,142	101,388	101,870	101,085
First stage F-stat	244.7	111.8	246.2	121.6	220.6	131.3	226.4	121.0	241.1	122.2

Note: The dependent variable is the logarithm of IT stock per unit of labor, capital, and cost. Standard errors are reported in brackets. In columns (1)-(4) we report results of IT per unit of labor, in columns (5)-(8) we report results for IT per unit of capital, and in columns (9) and (10) we report results of IT per unit of cost. The independent variable is the logarithm of firm size either proxied by sales or value added, instrumented by product demand shocks. The time period is 1997-2007. In panel 1 the sample is all exporting firms sampled by EAE, and in panel 3, the sample is exporting BRN firms. All columns include a full set of 3-digit industry classification fixed effects interacted with year fixed effects. An elasticity of 0.5656 of sofware stock per worker to sales means that raising sales by a factor of 2 raises software stock per worker by 56.56%. Observations are weighted by each firm's share of export in its total sales in 1995-1996.

Table OA.7: Reduced-Form Identification of the Size Elasticity of Relative IT Demand (Unweighted), Benchmark

	IT per Unit of Labor				IT per Unit of Capital				IT per Unit of Cost	
	Workers	Workers	Wage Bill	Wage Bill	Total	Total	Tangible	Tangible	Costs	Costs
Panel 1: Software (Stock)										
Size (proxied by sales)	1.2791		0.6703		1.0987		1.1197		0.9357	
	(0.3830)		(0.3768)		(0.3776)		(0.3806)		(0.3738)	
Size (proxied by VA)		1.5635		0.7303		1.2679		1.3100		1.0789
		(0.4911)		(0.4809)		(0.4751)		(0.4826)		(0.4785)
Observations	105,579	104,408	105,845	104,671	101,144	99,980	101,475	100,326	105,987	104,791
First stage F-stat	406.7	223.8	423.8	229.4	432.0	238.7	421.6	232.0	423.9	231.8
Panel 1: Hardware (Stock)										
Size (proxied by sales)	1.5248		1.0663		1.1005		1.0712		0.1791	
	(0.1264)		(0.1171)		(0.1173)		(0.1148)		(0.1049)	
Size (proxied by VA)		1.9228		1.3228		1.4229		1.3646		0.2618
		(0.1828)		(0.1597)		(0.1603)		(0.1569)		(0.1329)
Observations	99,294	98,353	99,982	99,110	100,005	99,142	100,175	99,309	99,944	99,086
First stage F-stat	420.9	223.5	415.8	224.1	411.1	220.6	421.6	223.4	418.8	227.2

Note: The dependent variable is the logarithm of IT stock per unit of labor, capital, and cost. Standard errors are reported in brackets. In columns (1)-(4) we report results of IT per unit of labor, in columns (5)-(8) we report results for IT per unit of capital, and in columns (9) and (10) we report results of IT per unit of cost. The independent variable is the logarithm of firm size either proxied by sales or value added, instrumented by product demand shocks. The time period is 1997-2007. In panel 1 the sample is all exporting firms sampled by EAE, and in panel 3, the sample is exporting BRN firms. All columns include a full set of 3-digit industry classification fixed effects interacted with year fixed effects. An elasticity of 1.3035 of sofware stock per worker to sales means that raising sales by a factor of 2 raises software stock per worker by 130.35%.

Table OA.7: Reduced-Form Identification of the Size Elasticity of Relative IT Demand (Unweighted), Alternative

	IT per Unit of Labor				IT per Unit of Capital				IT per Unit of Cost	
	Workers	Workers	Wage Bill	Wage Bill	Total	Total	Tangible	Tangible	Costs	Costs
Panel 1: Software (Stock)										
Size (proxied by sales)	1.8417		1.1781		1.6649		1.6324		1.4827	
	(0.4047)		(0.3975)		(0.4035)		(0.4019)		(0.3969)	
Size (proxied by VA)		2.1026		1.3711		1.9730		1.9512		1.6804
		(0.4963)		(0.4932)		(0.5002)		(0.4988)		(0.4915)
Observations	107,965	106,937	108,244	107,208	103,464	102,483	103,828	102,832	108,356	107,317
First stage F-stat	380.3	232.7	392.6	231.1	389.0	229.1	392.0	230.8	393.3	230.5
Panel 1: Hardware (Stock)										
Size (proxied by sales)	1.5366		1.0178		1.1464		1.0892		0.1484	
	(0.1288)		(0.1178)		(0.1230)		(0.1200)		(0.1077)	
Size (proxied by VA)		1.8922		1.2814		1.4610		1.4098		0.2219
		(0.1805)		(0.1574)		(0.1602)		(0.1575)		(0.1339)
Observations	101,903	100,961	102,560	101,749	102,568	101,767	102,746	101,977	102,508	101,696
First stage F-stat	399.0	221.2	394.1	220.0	378.4	221.5	387.9	222.4	387.2	215.5

Note: The dependent variable is the logarithm of IT stock per unit of labor, capital, and cost. Standard errors are reported in brackets. In columns (1)-(4) we report results of IT per unit of labor, in columns (5)-(8) we report results for IT per unit of capital, and in columns (9) and (10) we report results of IT per unit of cost. The independent variable is the logarithm of firm size either proxied by sales or value added, instrumented by product demand shocks. The time period is 1997-2007. In panel 1 the sample is all exporting firms sampled by EAE, and in panel 3, the sample is exporting BRN firms. All columns include a full set of 3-digit industry classification fixed effects interacted with year fixed effects. An elasticity of 1.3035 of sofware stock per worker to sales means that raising sales by a factor of 2 raises software stock per worker by 130.35%.

OA.5 Details on the Estimation Strategy and Results

Table OA.8: Estimation Results: Alternative Specifications, Benchmark

		Nonhomothetic CES	CES	*S-H* Comp.	IT Labor	Gross Output
Scale-dependence parameter	ϵ	0.433		0.325	0.436	0.252
		(0.026)		(0.018)	(0.018)	(0.008)
Elasticity of substitution	σ	0.280	0.170	0.106	0.303	0.128
		(0.034)	(0.041)	(0.018)	(0.020)	(0.011)
Cost elasticity parameter	γ	0.939	0.975	0.926	0.899	0.971
		(0.004)	(0.004)	(0.004)	(0.006)	(0.002)
Observations	N	307504	307504	307504	222938	306989

Note: Results of the estimation procedure for the pooled sample of all firms using different specifications for firm-level technology. Standard errors are reported in brackets. Columns 2 presents the estimated model parameters for a CES production function (where ϵ is constrained to be 0). Columns 3 presents the estimated model parameters for a production function featuring software/hardware complementarity. Column 4 presents the estimated model parameters for a production function with IT labor. Column 5 presents the estimated model parameters for a gross output production function.

Table OA.8: Estimation Results: Alternative Specifications, Alternative

		Nonhomothetic CES	CES	*S-H* Comp.	IT Labor	Gross Output
Scale-dependence parameter	ϵ	0.422		0.345	0.537	0.164
		(0.010)		(0.020)	(0.018)	(0.011)
Elasticity of substitution	σ	0.264	0.153	0.108	0.318	0.024
		(0.013)	(0.011)	(0.019)	(0.015)	(0.018)
Cost elasticity parameter	γ	0.946	0.964	0.944	0.875	1.029
		(0.004)	(0.004)	(0.005)	(0.007)	(0.009)
Observations	N	310229	310229	310229	226031	309604

Note: Results of the estimation procedure for the pooled sample of all firms using different specifications for firm-level technology. Standard errors are reported in brackets. Columns 2 presents the estimated model parameters for a CES production function (where ϵ is constrained to be 0). Columns 3 presents the estimated model parameters for a production function featuring software/hardware complementarity. Column 4 presents the estimated model parameters for a production function with IT labor. Column 5 presents the estimated model parameters for a gross output production function

Table OA.9: Estimation Results: Decomposition of the Cross-Sectional IT Intensity-Size Relationship, Benchmark

Specification	κ_I	$(1-\sigma)\epsilon$	κ_w	κ_ϕ	ϵ	σ
nhCES	0.22	0.31	−0.03	0.10	0.43	0.28
CES	0.22	0	−0.03	−0.29	0	0.17
CES (with nhCES σ)	0.22	0	−0.03	−0.33	0	0.28

Note: Results of the decomposition of the cross-sectional relationship between relative IT demand and firm size based on Equation (OA.5.1) for three specifications: nhCES, CES, and CES using the elasticity of substitution estimated for the nhCES specifications.

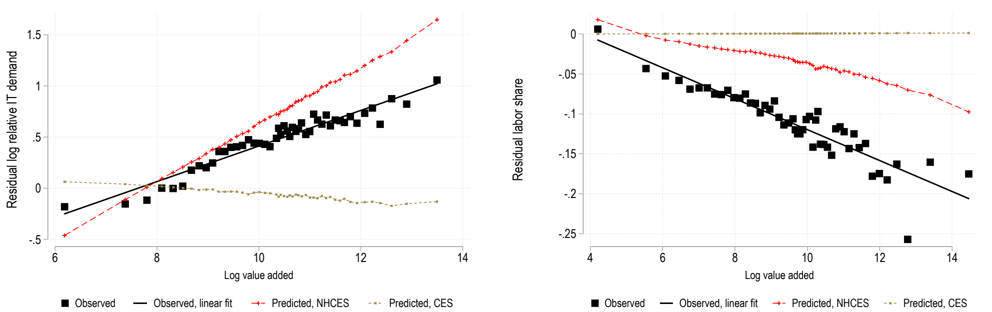
Table OA.9: Estimation Results: Decomposition of the Cross-Sectional IT Intensity-Size Relationship, Alternative

Specification	κ_I	$(1-\sigma)\epsilon$	κ_w	κ_ϕ	ϵ	σ
nhCES	0.22	0.31	−0.03	0.09	0.42	0.26
CES	0.22	0	−0.03	−0.29	0	0.15
CES (with nhCES σ)	0.22	0	−0.03	−0.33	0	0.26

Note: Results of the decomposition of the cross-sectional relationship between relative IT demand and firm size based on Equation (OA.5.1) for three specifications: nhCES, CES, and CES using the elasticity of substitution estimated for the nhCES specifications.

Figure OA.2: Cross-Sectional Facts: With and Without Scale Dependence, Benchmark

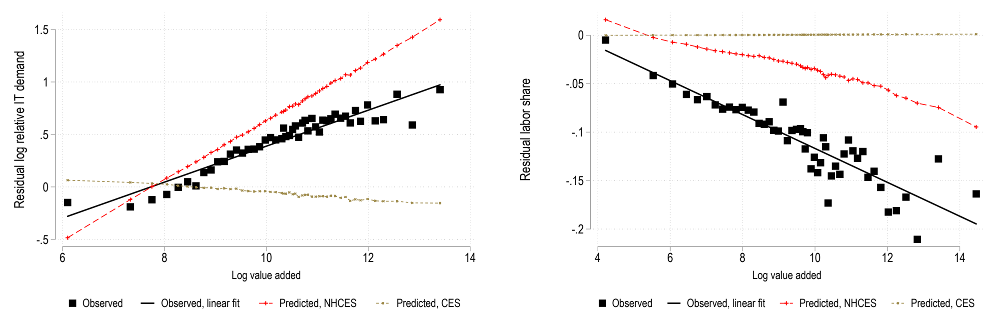
(a) Relative IT Demand and Firm Scale (b) Labor Share and Firm Scale



Note: Panel (a) presents the binscatter plot of log relative IT demand ($x_{I,it} - x_{N,it}$) and log firm value added (y_{it}), conditional on industry-time fixed effects in the data. The relationship in the data is compared with the predictions of the estimated nhCES and CES demand systems, without accounting for IT-augmenting productivity. Panel (b) presents the binscatter plot of labor share and log firm value added (y_{it}), conditional on industry-time fixed effects in the data. The relationship is compared with the predictions of the estimated nhCES and CES demand systems, without accounting for IT-augmenting productivity.

Figure OA.2: Cross-Sectional Facts: With and Without Scale Dependence, Alternative

(a) Relative IT Demand and Firm Scale (b) Labor Share and Firm Scale



Note: Panel (a) presents the binscatter plot of log relative IT demand ($x_{I,it} - x_{N,it}$) and log firm value added (y_{it}), conditional on industry-time fixed effects in the data. The relationship in the data is compared with the predictions of the estimated nhCES and CES demand systems, without accounting for IT-augmenting productivity. Panel (b) presents the binscatter plot of labor share and log firm value added (y_{it}), conditional on industry-time fixed effects in the data. The relationship is compared with the predictions of the estimated nhCES and CES demand systems, without accounting for IT-augmenting productivity.

Table OA.10: Identification of Scale-Dependence (ϵ) and Elasticity of Substitution (σ), Benchmark

	Scale-dependence	Elasticity of substitution
OLS Estimation	0.2774	-0.3017
	(0.0008)	(0.0066)
Observations	307,504	4,135
R2	0.2937	0.3329
First Stage	0.9822	-0.0384
	(0.0005)	(0.0125)
Observations	307,504	4,135
R2	0.9200	0.0023
First stage F-stat		9.372
Reduced Form	0.3045	0.0218
	(0.0008)	(0.0066)
Observations	307,504	4,135
R2	0.3376	0.0027
Second Stage	0.3101	-0.5672
	(0.0008)	(0.1707)
Observations	307,504	4,135
R2	0.3376	0.0027

Note: This table reports the relationships in the data between software stock per worker (minus the controls), and the logarithms of value added and relative price of software, and their respective instruments, the logarithm of lagged value added and the shift-share instrument for local labor demand. Standard errors are reported in brackets. In the first and in the second columns, OLS corresponds to a simple regression of software stock per worker (minus the controls) on RHS (corresponding to Equations OA.5.7 and OA.5.6, respectively), first stage to a regression of RHS on its instrument, reduced form to a regression of software stock per worker (minus the controls) on the instrument, and second stage to a regression of software stock per worker (minus the controls) on the predicted value of RHS from the first stage. First-stage F-stat for lagged instrument is very large. For the identification of σ, firms' outcomes are averaged at the local × year level, regressions are weighted by the number of firms at each location × year. The sample of firms corresponds to the estimation results reported in Table 2 (All industries).

Table OA.10: Identification of Scale-Dependence (ϵ) and Elasticity of Substitution (σ), Alternative

	Scale-dependence	Elasticity of substitution
OLS Estimation	0.2761	-0.2944
	(0.0008)	(0.0068)
Observations	310,229	4,135
R2	0.2929	0.3124
First Stage	0.9813	-0.0430
	(0.0005)	(0.0126)
Observations	310,229	4,135
R2	0.9191	0.0028
First stage F-stat		11.627
Reduced Form	0.3041	0.0208
	(0.0008)	(0.0066)
Observations	310,229	4,135
R2	0.3392	0.0024
Second Stage	0.3099	-0.4824
	(0.0008)	(0.1545)
Observations	310,229	4,135
R2	0.3392	0.0024

Note: This table reports the relationships in the data between software stock per worker (minus the controls), and the logarithms of value added and relative price of software, and their respective instruments, the logarithm of lagged value added and the shift-share instrument for local labor demand. Standard errors are reported in brackets. In the first and in the second columns, OLS corresponds to a simple regression of software stock per worker (minus the controls) on RHS (corresponding to Equations OA.5.7 and OA.5.6, respectively), first stage to a regression of RHS on its instrument, reduced form to a regression of software stock per worker (minus the controls) on the instrument, and second stage to a regression of software stock per worker (minus the controls) on the predicted value of RHS from the first stage. First-stage F-stat for lagged instrument is very large. For the identification of σ, firms' outcomes are averaged at the local × year level, regressions are weighted by the number of firms at each location × year. The sample of firms corresponds to the estimation results reported in Table 2 (All industries).

Table OA.11: Identification of Scale-dependence (ϵ) and Elasticity of Substitution (σ), Exporting Firms, Benchmark

	Scale-dependence		Elasticity of substitution
	Lagged Valued Added IV	Export Demand IV	
OLS Estimation	0.2832	0.2832	-0.2752
	(0.0013)	(0.0013)	(0.0087)
Observations	99,421	99,421	3,717
R2	0.3141	0.3141	0.2134
First Stage	0.9819	0.0343	-0.0423
	(0.0007)	(0.0007)	(0.0127)
Observations	99,421	99,421	3,717
R2	0.9453	0.0210	0.0030
First stage F-stat		2133.907	11.134
Reduced Form	0.2946	0.0110	0.0184
	(0.0013)	(0.0004)	(0.0076)
Observations	99,421	99,421	3,717
R2	0.3334	0.0085	0.0016
Second Stage	0.3001	0.3210	-0.4344
	(0.0013)	(0.0110)	(0.1787)
Observations	99,421	99,421	3,717
R2	0.3334	0.0085	0.0016

Note: This table reports the relationships in the data between software stock per worker (minus the controls), and the logarithms of value added and relative price of software, and their respective instruments, the logarithm of lagged value added and the shift-share instrument for local labor demand. Standard errors are reported in brackets. In the first and in the second columns, OLS corresponds to a simple regression of software stock per worker (minus the controls) on RHS (corresponding to Equations OA.5.7 and OA.5.6, respectively), first stage to a regression of RHS on its instrument, reduced form to a regression of software stock per worker (minus the controls) on the instrument, and second stage to a regression of software stock per worker (minus the controls) on the predicted value of RHS from the first stage. First-stage F-stat for lagged instrument is very large, and due to differences in specification and choice of clustering, F-stat for export instrument reported here differs from Table 1 in the main text. For the identification of σ, firms' outcomes are averaged at the local $\times$ year level, regressions are weighted by the number of firms at each location $\times$ year. The sample, exporting firms, is narrower than in the estimation results reported in Table 2 in the main text.

Table OA.11: Identification of Scale-dependence (ϵ) and Elasticity of Substitution (σ), Exporting Firms, Alternative

	Scale-dependence		Elasticity of substitution
	Lagged Valued Added IV	Export Demand IV	
OLS Estimation	0.2809	0.2809	-0.2518
	(0.0013)	(0.0013)	(0.0087)
Observations	99,794	99,794	3,718
R2	0.3144	0.3144	0.1828
First Stage	0.9824	0.0339	-0.0483
	(0.0007)	(0.0007)	(0.0129)
Observations	99,794	99,794	3,718
R2	0.9461	0.0203	0.0038
First stage F-stat		2063.039	14.045
Reduced Form	0.2921	0.0108	0.0136
	(0.0013)	(0.0004)	(0.0076)
Observations	99,794	99,794	3,718
R2	0.3332	0.0081	0.0009
Second Stage	0.2973	0.3173	-0.2816
	(0.0013)	(0.0111)	(0.1573)
Observations	99,794	99,794	3,718
R2	0.3332	0.0081	0.0009

Note: This table reports the relationships in the data between software stock per worker (minus the controls), and the logarithms of value added and relative price of software, and their respective instruments, the logarithm of lagged value added and the shift-share instrument for local labor demand. Standard errors are reported in brackets. In the first and in the second columns, OLS corresponds to a simple regression of software stock per worker (minus the controls) on RHS (corresponding to Equations OA.5.7 and OA.5.6, respectively), first stage to a regression of RHS on its instrument, reduced form to a regression of software stock per worker (minus the controls) on the instrument, and second stage to a regression of software stock per worker (minus the controls) on the predicted value of RHS from the first stage. First-stage F-stat for lagged instrument is very large, and due to differences in specification and choice of clustering, F-stat for export instrument reported here differs from Table 1 in the main text. For the identification of σ, firms' outcomes are averaged at the local $\times$ year level, regressions are weighted by the number of firms at each location $\times$ year. The sample, exporting firms, is narrower than in the estimation results reported in Table 2 in the main text.

Table OA.12: Correlations Between Non-Flexible Relative to Flexible Inputs and the Instrument for Size, Benchmark

	Non IT Capital Stock per Worker	Hardware to Software Stock Ratio
Shift-Share Instrument	-0.0204	-0.1104
	(0.0054)	(0.0242)
Observations	121,886	121,886

Note: The dependent variable is the log capital to labor ratio in column (1), and the log hardware to software ratio in column (2). Standard errors are reported in brackets. The independent variable is the instrument used in the IV regressions, here product demand shocks. The time period is 1995-2007. All columns include a full set of 3-digit industry classification fixed effects interacted with year fixed effects.

Table OA.12: Correlations Between Non-Flexible Relative to Flexible Inputs and the Instrument for Size, Alternative

	Non IT Capital Stock per Worker	Hardware to Software Stock Ratio
Shift-Share Instrument	-0.0202	-0.1296
	(0.0055)	(0.0242)
Observations	122,040	122,040

Note: The dependent variable is the log capital to labor ratio in column (1), and the log hardware to software ratio in column (2). Standard errors are reported in brackets. The independent variable is the instrument used in the IV regressions, here product demand shocks. The time period is 1995-2007. All columns include a full set of 3-digit industry classification fixed effects interacted with year fixed effects.

Table OA.13: Estimation Results, Benchmark

		All Industries			Manufacturing		
		nhCES	CES	CD	nhCES	CES	CD
Scale-dependence paramater	ϵ	0.433			0.466		
		(0.026)			(0.027)		
Elasticity of substitution	σ	0.280	0.170		0.131	0.041	
		(0.034)	(0.041)		(0.036)	(0.061)	
Cost elasticity parameter	γ	0.939	0.975	0.985	0.946	1.004	1.012
		(0.004)	(0.004)	(0.004)	(0.006)	(0.006)	(0.008)
Capital elasticity of non-IT	α	0.062	0.058	0.061	0.146	0.146	0.165
		(0.003)	(0.003)	(0.005)	(0.007)	(0.007)	(0.011)
Software elasticity of IT	β	0.042	0.127	-0.176	0.152	0.239	0.171
		(0.034)	(0.032)	(0.050)	(0.034)	(0.036)	(0.063)
Persistence of θ	$\rho_{\theta\theta}$	0.839	0.832	0.821	0.842	0.826	0.831
		(0.003)	(0.003)	(0.002)	(0.004)	(0.004)	(0.004)
Persistence of θ wrt ϕ	$\rho_{\theta\phi}$	-0.008	-0.010		-0.008	-0.013	
		(0.001)	(0.001)		(0.001)	(0.001)	
Persistence of ϕ wrt θ	$\rho_{\phi\theta}$	-0.058	-0.037		-0.049	-0.032	
		(0.004)	(0.003)		(0.004)	(0.004)	
Persistence of ϕ	$\rho_{\phi\phi}$	0.899	0.909		0.900	0.920	
		(0.001)	(0.001)		(0.002)	(0.002)	
Trend for θ	μ_θ	0.002	0.002	-0.004	0.003	0.003	0.001
		(0.000)	(0.000)		(0.000)	(0.000)	
Trend for ϕ	μ_ϕ	0.008	0.008		-0.008	-0.004	
		(0.001)	(0.001)		(0.001)	(0.001)	
Shifter for θ	η_θ	0.556	0.602	0.667	0.474	0.575	0.560
		(0.013)	(0.013)		(0.016)	(0.017)	
Shifter for ϕ	η_ϕ	0.701	0.171		0.715	0.190	
		(0.056)	(0.030)		(0.046)	(0.034)	
Observations	N	307504	307504	312981	148979	148979	150773

Note: Results of the estimation procedure for the pooled sample of all firms. Standard errors are reported in brackets. Columns 1 presents the estimated model parameters for a production function featuring software/hardware complementarity. Column 2 presents the estimated model parameters for a production function with IT labor. Column 3 presents the estimated model parameters for a gross output production function.

Table OA.13: Estimation Results, Alternative

		All Industries			Manufacturing		
		nhCES	CES	CD	nhCES	CES	CD
Scale-dependence paramater	ϵ	0.422			0.542		
		(0.010)			(0.012)		
Elasticity of substitution	σ	0.264	0.153		0.252	0.082	
		(0.013)	(0.011)		(0.015)	(0.040)	
Cost elasticity parameter	γ	0.946	0.964	0.981	0.950	1.009	1.021
		(0.004)	(0.004)	(0.006)	(0.005)	(0.006)	(0.008)
Capital elasticity of non-IT	α	0.068	0.061	0.063	0.139	0.136	0.160
		(0.004)	(0.004)	(0.006)	(0.006)	(0.007)	(0.010)
Software elasticity of IT	β	0.003	0.126	-0.375	0.002	0.204	0.180
		(0.023)	(0.016)	(0.070)	(0.034)	(0.029)	(0.055)
Persistence of θ	$\rho_{\theta\theta}$	0.843	0.842	0.822	0.838	0.834	0.828
		(0.003)	(0.003)	(0.002)	(0.004)	(0.004)	(0.004)
Persistence of θ wrt ϕ	$\rho_{\theta\phi}$	-0.008	-0.009		-0.008	-0.014	
		(0.000)	(0.001)		(0.001)	(0.001)	
Persistence of ϕ wrt θ	$\rho_{\phi\theta}$	-0.061	-0.038		-0.057	-0.030	
		(0.003)	(0.003)		(0.004)	(0.003)	
Persistence of ϕ	$\rho_{\phi\phi}$	0.895	0.907		0.900	0.921	
		(0.001)	(0.001)		(0.002)	(0.001)	
Trend for θ	μ_θ	0.002	0.002	-0.007	0.003	0.003	0.001
		(0.000)	(0.000)		(0.000)	(0.000)	
Trend for ϕ	μ_ϕ	0.005	0.006		-0.009	-0.004	
		(0.001)	(0.001)		(0.001)	(0.001)	
Shifter for θ	η_θ	0.549	0.549	0.670	0.503	0.572	0.585
		(0.013)	(0.013)		(0.017)	(0.018)	
Shifter for ϕ	η_ϕ	0.729	0.170		0.891	0.197	
		(0.022)	(0.015)		(0.021)	(0.025)	
Observations	N	310229	310229	315186	157357	157357	159066

Note: Results of the estimation procedure for the pooled sample of all firms. Standard errors are reported in brackets. Columns 1 presents the estimated model parameters for a production function featuring software/hardware complementarity. Column 2 presents the estimated model parameters for a production function with IT labor. Column 3 presents the estimated model parameters for a gross output production function.

Table OA.14: Estimation Results: Alternative Specifications, Benchmark

		All Industries		
		S-H Comp.	IT Labor	Gross Output
Scale-dependence parameter	ϵ	0.325	0.436	0.252
		(0.018)	(0.018)	(0.008)
Elasticity of substitution	σ	0.106	0.303	0.128
		(0.018)	(0.020)	(0.011)
Cost elasticity parameter	γ	0.926	0.899	0.971
		(0.004)	(0.006)	(0.002)
Capital elasticity of non-IT	α	0.072	0.016	0.001
		(0.004)	(0.007)	(0.003)
Materials elasticity of non-IT	α_M			0.627
				(0.008)
Software elasticity of IT	β	0.043	0.000	0.276
		(0.018)	(0.033)	(0.017)
IT Labor elasticity of IT	β_T		0.434	
			(0.036)	
Persistence of θ	$\rho_{\theta\theta}$	0.851	0.863	0.886
		(0.003)	(0.003)	(0.002)
Persistence of θ wrt ϕ	$\rho_{\theta\phi}$	-0.007	-0.013	-0.002
		(0.000)	(0.001)	(0.000)
Persistence of ϕ wrt θ	$\rho_{\phi\theta}$	-0.057	-0.012	-0.041
		(0.003)	(0.004)	(0.005)
Persistence of ϕ	$\rho_{\phi\phi}$	0.887	0.914	0.903
		(0.004)	(0.001)	(0.001)
Trend for θ	μ_θ	0.002	0.003	-0.001
		(0.000)	(0.000)	(0.000)
Trend for ϕ	μ_ϕ	0.004	0.014	0.011
		(0.002)	(0.001)	(0.001)
Shifter for θ	η_θ	0.473	0.527	0.251
		(0.014)	(0.015)	(0.005)
Shifter for ϕ	η_ϕ	0.524	0.499	0.596
		(0.020)	(0.028)	(0.017)
Observations	N	307504	222938	306989

Note: Results of the estimation procedure for the pooled sample of all firms in (columns 1-3), and for the pooled sample of manufacturing firms (columns 4-6). Standard errors are reported in brackets. Columns 2 and 5 present the estimated model parameters for a CES production function (where ϵ is constrained to be 0). Columns 3 and 6 present the estimated model parameters for a Cobb-Douglas production function (where σ is additionally constrained to be 1).

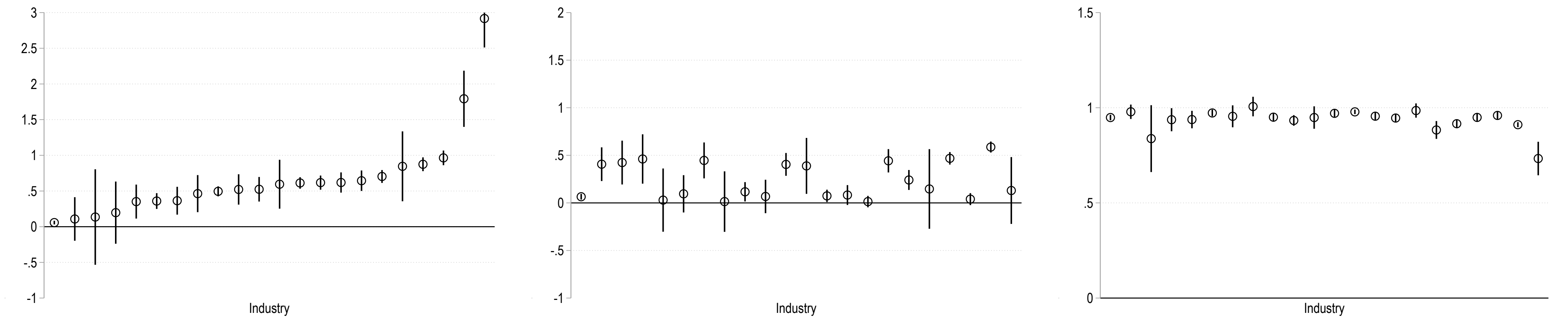
Table OA.14: Estimation Results: Alternative Specifications, Alternative

		All Industries		
		S-H Comp.	IT Labor	Gross Output
Scale-dependence parameter	ϵ	0.345	0.537	0.164
		(0.020)	(0.018)	(0.011)
Elasticity of substitution	σ	0.108	0.318	0.024
		(0.019)	(0.015)	(0.018)
Cost elasticity parameter	γ	0.944	0.875	1.029
		(0.005)	(0.007)	(0.009)
Capital elasticity of non-IT	α	0.088	0.000	0.221
		(0.004)	(0.008)	(0.012)
Materials elasticity of non-IT	α_M			0.859
				(0.019)
Software elasticity of IT	β	0.026	0.000	0.307
		(0.010)	(0.032)	(0.016)
IT Labor elasticity of IT	β_T		0.477	
			(0.042)	
Persistence of θ	$\rho_{\theta\theta}$	0.851	0.870	0.951
		(0.003)	(0.003)	(0.001)
Persistence of θ wrt ϕ	$\rho_{\theta\phi}$	-0.008	-0.011	-0.004
		(0.000)	(0.001)	(0.000)
Persistence of ϕ wrt θ	$\rho_{\phi\theta}$	-0.057	-0.021	-0.111
		(0.003)	(0.004)	(0.003)
Persistence of ϕ	$\rho_{\phi\phi}$	0.887	0.908	0.902
		(0.004)	(0.001)	(0.001)
Trend for θ	μ_θ	0.002	0.003	-0.002
		(0.000)	(0.000)	(0.000)
Trend for ϕ	μ_ϕ	0.002	0.016	0.008
		(0.001)	(0.001)	(0.001)
Shifter for θ	η_θ	0.496	0.483	0.063
		(0.013)	(0.013)	(0.005)
Shifter for ϕ	η_ϕ	0.572	0.651	0.660
		(0.020)	(0.021)	(0.014)
Observations	N	310229	226031	309604

Note: Results of the estimation procedure for the pooled sample of all firms in (columns 1-3), and for the pooled sample of manufacturing firms (columns 4-6). Standard errors are reported in brackets. Columns 2 and 5 present the estimated model parameters for a CES production function (where ϵ is constrained to be 0). Columns 3 and 6 present the estimated model parameters for a Cobb-Douglas production function (where σ is additionally constrained to be 1).

Figure OA.3: Industry-Level Estimates, Benchmark

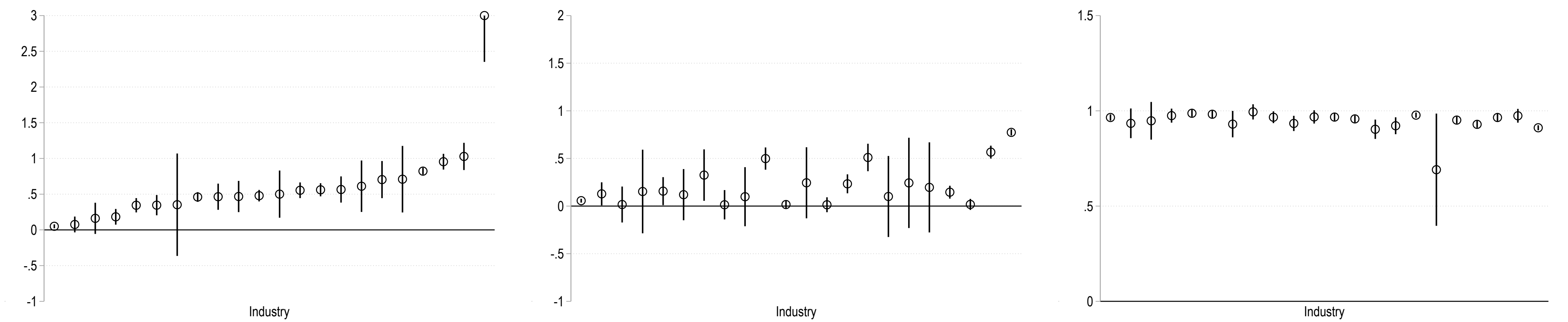
(a) Scale-Dependence Parameter ϵ (b) Substitution Elasticity σ (c) Cost Elasticity Parameter γ



Note: This figure presents the estimated values of the parameters ϵ, σ and γ across 17 industries of the market economy (level A38 of the NAF classification) in France. The bands around the estimates show the 90% confidence intervals. Industries are sorted from lowest to largest ϵ, as in Table OA.30. For three industries (Transportation, Legal, Accounting and Engineering, and Administrative and Support), we constraint the elasticity of substitution to be positive in the non-linear stage by replacing σ with $exp(log(\sigma))$ for the first two industries by $(\sqrt{\sigma})^2$ for the third industry.

Figure OA.3: Industry-Level Estimates, Alternative

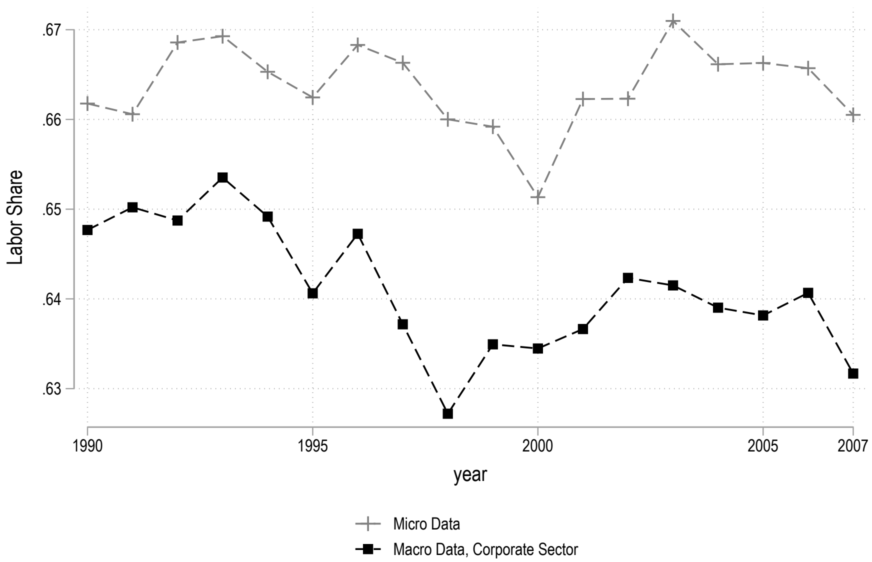
(a) Scale-Dependence Parameter ϵ (b) Substitution Elasticity σ (c) Cost Elasticity Parameter γ



Note: This figure presents the estimated values of the parameters ϵ, σ and γ across 17 industries of the market economy (level A38 of the NAF classification) in France. The bands around the estimates show the 90% confidence intervals. Industries are sorted from lowest to largest ϵ, as in Table OA.30. For three industries (Transportation, Legal, Accounting and Engineering, and Administrative and Support), we constraint the elasticity of substitution to be positive in the non-linear stage by replacing σ with $exp(log(\sigma))$ for the first two industries by $(\sqrt{\sigma})^2$ for the third industry.

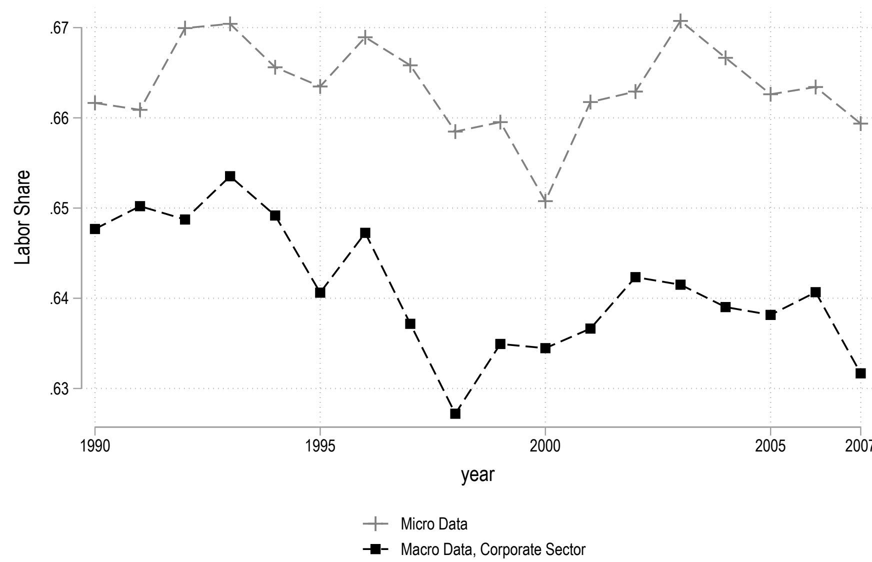
OA.6 Details on the Empirical Application to French Macro Trends

Figure OA.4: Aggregate Labor Share, Benchmark



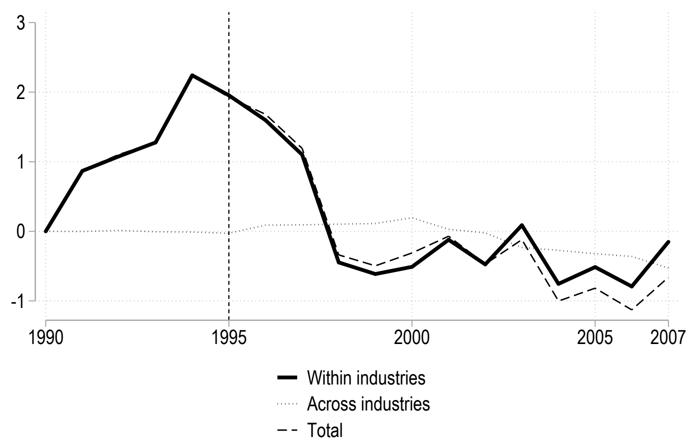
Note: This figures reports the ratio of employee compensation, including payroll taxes, to total value-added in the market sectors in France. Micro data refers to the aggregate labor share in the BRN+RSI data, excluding observations with labor share higher than 3.3 and negative values. Macro data refers to the corporate sector in France, which includes sectors such as real estate, finance, and agriculture.

Figure OA.4: Aggregate Labor Share, Alternative



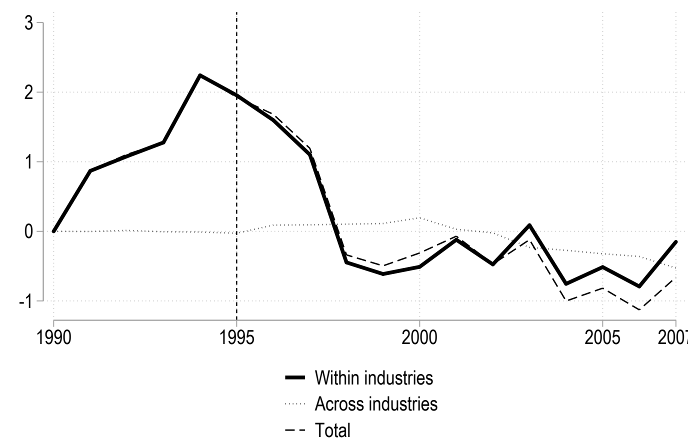
Note: This figures reports the ratio of employee compensation, including payroll taxes, to total value-added in the market sectors in France. Micro data refers to the aggregate labor share in the BRN+RSI data, excluding observations with labor share higher than 3.3 and negative values. Macro data refers to the corporate sector in France, which includes sectors such as real estate, finance, and agriculture.

Figure OA.5: Capital Share Decomposition, Benchmark



Note: This figure presents the cumulative change in the total capital share, as well as the decomposition of this change to within and across-industry components (at the level of A38 industries).

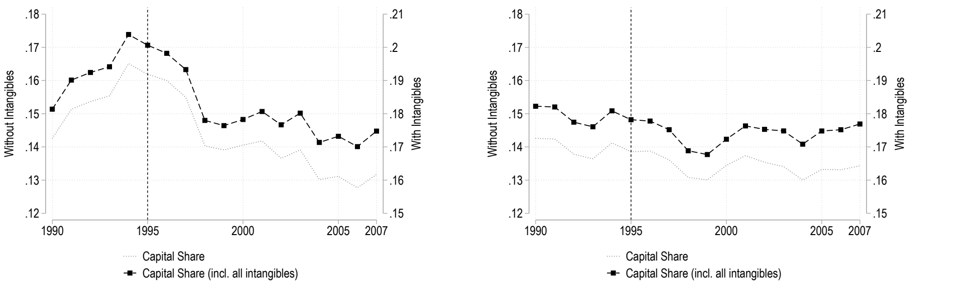
Figure OA.5: Capital Share Decomposition, Alternative



Note: This figure presents the cumulative change in the total capital share, as well as the decomposition of this change to within and across-industry components (at the level of A38 industries).

Figure OA.6: Aggregate Capital Share, Benchmark

(a) Varying $\mathbb{E}[\pi_s]$ (b) Constant $\mathbb{E}[\pi_s]$



Note: This figure reports the ratio of payments to capital, to total value-added in the market sectors in France, excluding agriculture, finance and real estate. Capital share includes all intangible assets that are considerered as such in national accounts (software and databases, research and development, and intellectual property). Supplementary intangibles are marketing activities, design, training, and purchased and in-house organizational capital.

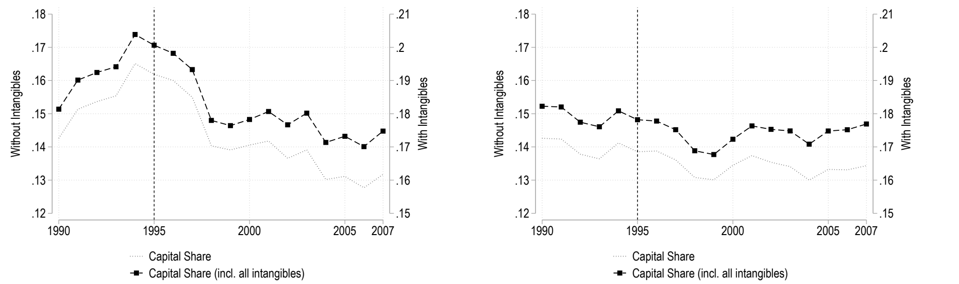
Table OA.15: Aggregate-Level Changes in France (1995-2007): Data vs. Model Predictions, Alternative Shock, Benchmark

Change in Aggregate Variable		Data	Model (Alt.)	Model (correction)
Relative IT Price	W		-46.0%	-70.3%
Aggregate Output	$\overline{Y}$	19.1%	2.6%	5.0%
Price Index	$\overline{P}$	-15.7%	-2.5%	-4.8%
Share of Top 1% of Firms		6.3 p.p.	2.7 p.p.	5.2 p.p.
Share of Top 5% of Firms		4.0 p.p.	2.2 p.p.	4.2 p.p.
Labor Share	$\overline{FS}_L$	0.3 p.p.	-0.0 p.p.	-0.0 p.p.
Within contribution		1.3 p.p.	1.2 p.p.	2.3 p.p.
Between contribution		-1.0 p.p.	-1.2 p.p.	-2.3 p.p.
Profit Share		-0.0 p.p.	0.0 p.p.	0.0 p.p.

Note: The table shows the changes in the French aggregate output, its price (relative to the bundle of non-IT inputs), and the profit share (based on the official INSEE series), and in the concentration of production and labor share (based on our macro data) over the 1995-2007 period. The changes are compared with those predicted by the model in response to two different series for falling relative IT prices: alternative series based on INSEE data using the average price of Computers in Germany, the UK and the US, and that including the correction by Byrne and Corrado (2017). p.p. stands for "percentage points." % changes are expressed relative to the respective baseline in each model and in the data.

Figure OA.6: Aggregate Capital Share, Alternative

(a) Varying $\mathbb{E}[\pi_s]$ (b) Constant $\mathbb{E}[\pi_s]$



Note: This figure reports the ratio of payments to capital, to total value-added in the market sectors in France, excluding agriculture, finance and real estate. Capital share includes all intangible assets that are considerered as such in national accounts (software and databases, research and development, and intellectual property). Supplementary intangibles are marketing activities, design, training, and purchased and in-house organizational capital.

Table OA.15: Aggregate-Level Changes in France (1995-2007): Data vs. Model Predictions, Alternative Shock, Alternative

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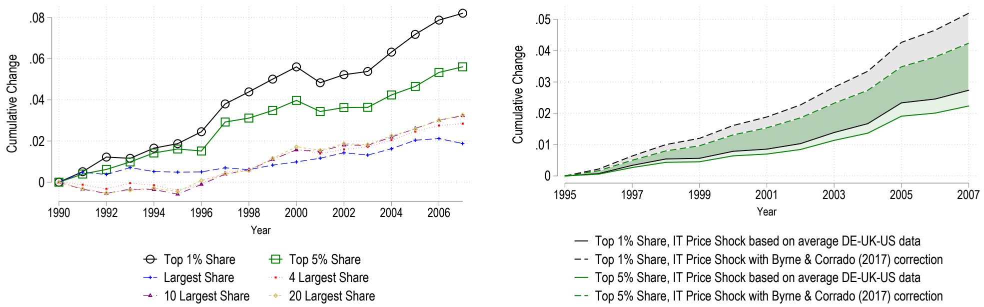
Relative IT Price	W		-46.0%	-70.3%
Aggregate Output	$\overline{Y}$	19.1%	2.6%	5.0%
Price Index	$\overline{P}$	-15.7%	-2.5%	-4.8%
Share of Top 1% of Firms		6.9 p.p.	2.3 p.p.	4.5 p.p.
Share of Top 5% of Firms		4.1 p.p.	1.8 p.p.	3.5 p.p.
Labor Share	$\overline{FS}_L$	-0.0 p.p.	0.0 p.p.	-0.0 p.p.
Within contribution		1.4 p.p.	1.2 p.p.	2.4 p.p.
Between contribution		-1.4 p.p.	-1.2 p.p.	-2.4 p.p.
Profit Share		0.3 p.p.	-0.0 p.p.	0.0 p.p.

Note: The table shows the changes in the French aggregate output, its price (relative to the bundle of non-IT inputs), and the profit share (based on the official INSEE series), and in the concentration of production and labor share (based on our macro data) over the 1995-2007 period. The changes are compared with those predicted by the model in response to two different series for falling relative IT prices: alternative series based on INSEE data using the average price of Computers in Germany, the UK and the US, and that including the correction by Byrne and Corrado (2017). p.p. stands for "percentage points." % changes are expressed relative to the respective baseline in each model and in the data.

Figure OA.7: Rise of Concentration in France: Data vs. Model Predictions, Alternative Shock, Benchmark

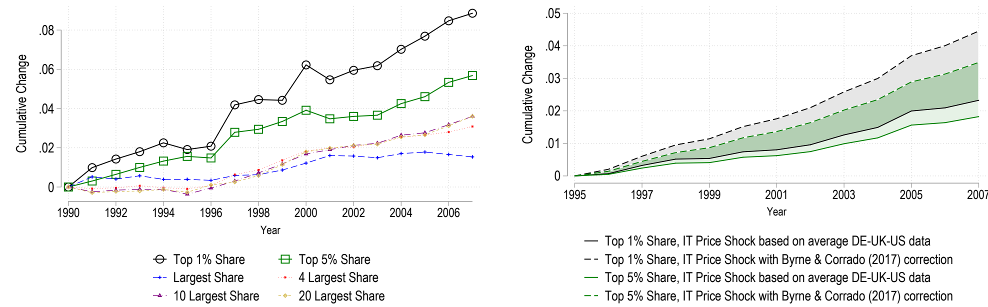
(a) Production Concentration in the Data (b) Response of Concentration to IT Shock



Note: Panel (a) presents the evolution of the sales-weighted averages (across 3-digits industries) of the cumulative change in concentration, measured as the share in total industry sales of the largest 1%, 5% , 1, 4, 10 or 20 firms. Panel (b) shows the cumulative changes in the shares of the largest 1% and 5% of firms predicted by the model in response to the two series for the relative IT prices over the 1995-2007 period.

Figure OA.7: Rise of Concentration in France: Data vs. Model Predictions, Alternative Shock, Alternative

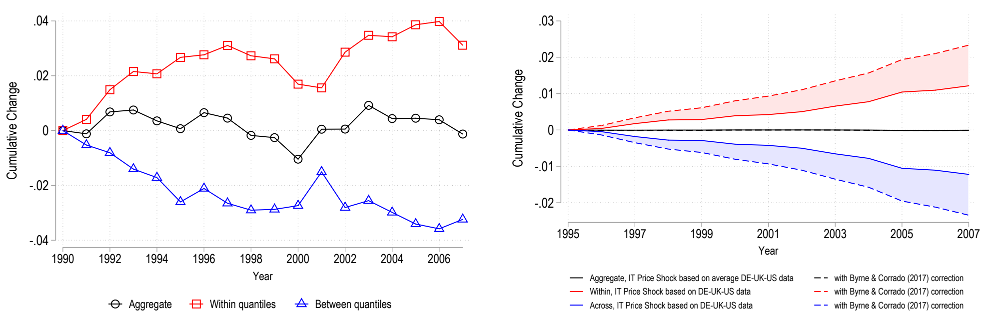
(a) Production Concentration in the Data (b) Response of Concentration to IT Shock



Note: Panel (a) presents the evolution of the sales-weighted averages (across 3-digits industries) of the cumulative change in concentration, measured as the share in total industry sales of the largest 1%, 5% , 1, 4, 10 or 20 firms. Panel (b) shows the cumulative changes in the shares of the largest 1% and 5% of firms predicted by the model in response to the two series for the relative IT prices over the 1995-2007 period.

Figure OA.8: Evolution of Labor Share in France: Data vs. Model Predictions, Alternative Shock, Benchmark

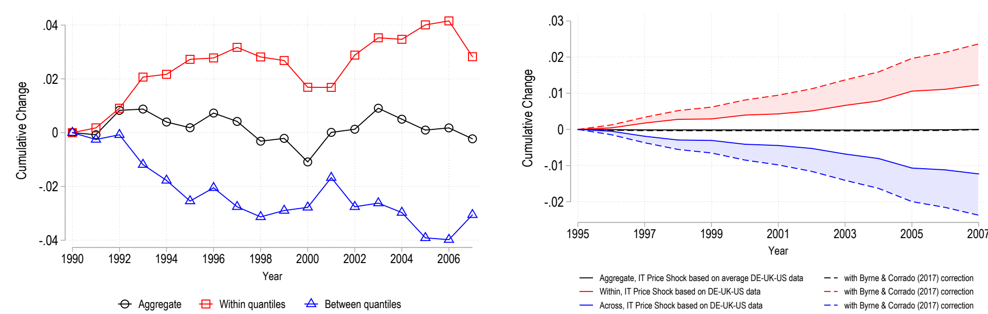
(a) Labor Share Decomposition (b) Response of Labor Share to IT Shock



Note: Note. Panel (a) presents the cumulative change in the aggregate labor share, as well as the decomposition of this change to within and across-firm components (at the level of 2-digit industries). Panel (b) shows the correpsonding responses predicted by the model to the two series for the relative IT prices over the 1995-2007 period.

Figure OA.8: Evolution of Labor Share in France: Data vs. Model Predictions, Alternative Shock, Alternative

(a) Labor Share Decomposition (b) Response of Labor Share to IT Shock



Note: Note. Panel (a) presents the cumulative change in the aggregate labor share, as well as the decomposition of this change to within and across-firm components (at the level of 2-digit industries). Panel (b) shows the correpsonding responses predicted by the model to the two series for the relative IT prices over the 1995-2007 period.

OA.7 Additional Tables

Table OA.16: Summary Statistics: Exporting vs All Firms, Benchmark

	Source	All firms Obs. (Nb)	Mean	Median	Sd	Exporting firms Obs. (Nb)	Mean	Median	Sd
Sales	BRN + RSI	15,202,793	2,498.8	265	85,057.3	1,773,652	12,592.8	1636	176,977.3
Value-Added	BRN + RSI	15,202,793	708.3	106	33,071.6	1,773,652	3,329.4	451.6	82,716.4
Number of Employees	BRN + RSI	15,202,793	13.8	3	480.7				
Wage Bill	BRN + RSI	15,202,793	472.4	74	18,404.6	1,773,652	2,107.2	345	46,396.1
Labor Share (%)	BRN + RSI	15,202,793	86.2	73.0	813.6	1,773,652	100.7	77.9	2,134.4
Total Investment	BRN	6,336,678	140.2	4.7	9,746.9	1,711,942	415.6	17	18,734.3
Total Capital Stock	BRN	6,336,678	1,205.9	88.6	92,054.5	1,711,942	3,706.8	230.3	176,922.7
Total Cost	BRN	6,336,677	888.2	180.3	33,090.3	1,711,942	2,339.8	368.1	63,154.2
IT Measures									
Software Investment	EAE	2,511,960	5.7	0	520.1	983,044	13.7	0	831.0
Software Stock	EAE	2,511,960	15.4	0	1,197.5	983,044	37.1	0	1,913.7
Hardware Investment	BRN	6,336,678	5.9	0	399.9	1,711,942	17.5	0	767.6
Hardware Stock	BRN	6,336,678	24.0	0	1,832.4	1,711,942	77.3	0.4	3,522.3
IT per Worker									
Software Investment	EAE	2,511,960	27.1	0	165.2	983,044	52.2	0	224.8
Software Stock	EAE	2,511,960	80.9	0	3,165.3	983,044	158.8	0	4,900.4
Hardware Investment	BRN	6,336,678	171.7	0	786.3	1,711,942	201.2	0	780.9
Hardware Stock	BRN	6,336,678	472.2	0	2,412.0	1,711,942	662.0	32.7	2,951.3
IT per Unit of Capital									
Software Investment	EAE	2,046,011	21.5	0	1,184.9	883,394	30.7	0	1,452.9
Software Stock	EAE	2,359,661	3.9	0	28.6	952,265	5.4	0	26.4
Hardware Investment	BRN	4,498,705	109.0	0	1,748.3	1,418,133	108.3	0	2,963.7
Hardware Stock	BRN	5,716,575	38.7	0	127.0	1,617,087	35.2	1.8	103.8
IT per Unit of Cost									
Software Investment	EAE	2,511,953	0.6	0	4.1	983,044	1.2	0	5.2
Software Stock	EAE	2,511,960	0.6	0	2.9	983,044	1.1	0	3.6
Hardware Investment	BRN	6,336,632	3.7	0	28.1	1,711,939	4.1	0	29.0
Hardware Stock	BRN	6,336,677	2.3	0	7.8	1,711,942	3.0	0.2	7.2

Note: The units for all variables are thousand euros except for those involving intensity, share, or numbers. The units for the IT intensity of labor, capital, and cost are euros per worker, euros per thousand euros of capital, and euros per thousand euros of cost, respectively. Labor share, in percentage points, is defined as the sum of wage bill and payroll taxes divided by value-added. Stock measures are built using the Perpetual Inventory Method (PIM), imputing zero investment for missing data. The table reports hardware and capital inputs for all firms included at least once in the BRN files, and software inputs for all firms surveyed at least once by EAE. Data Appendix OA.2 in the main text describes the sources for each variable. The period is 1990-2007 for BRN + RSI data, 1995-2007 for BRN and EAE data. For the IT intensity of capital, the number of non missing observations is lower because of the higher occurrence of zeros in the denominator.

Table OA.16: Summary Statistics: Exporting vs All Firms, Alternative

	Source	All firms Obs. (Nb)	Mean	Median	Sd	Exporting firms Obs. (Nb)	Mean	Median	Sd
Sales	BRN + RSI	15,459,261	2,534.3	266	85,495.8	1,803,770	12,779.0	1640	179,629.8
Value-Added	BRN + RSI	15,459,261	717.1	107	33,014.9	1,803,770	3,361.4	454.3	82,547.4
Number of Employees	BRN + RSI	15,459,261	13.9	3	479.9				
Wage Bill	BRN + RSI	15,459,261	478.2	74.2	18,451.8	1,803,770	2,134.3	347	46,567.0
Labor Share (%)	BRN + RSI	15,459,261	86.2	72.9	809.6	1,803,770	100.6	77.8	2,118.1
Total Investment	BRN	6,464,255	141.6	4.7	9,738.9	1,741,227	420.6	17	18,747.1
Total Capital Stock	BRN	6,464,255	1,214.6	88.9	91,598.6	1,741,227	3,742.5	234.5	176,311.2
Total Cost	BRN	6,464,254	894.4	181.1	33,143.7	1,741,227	2,367.3	370.8	63,360.2
IT Measures									
Software Investment	EAE	2,569,390	5.8	0	515.3	1,003,509	13.9	0	824.2
Software Stock	EAE	2,569,390	15.6	0	1,188.6	1,003,509	37.8	0	1,901.5
Hardware Investment	BRN	6,464,255	5.9	0	399.2	1,741,227	17.8	0	767.5
Hardware Stock	BRN	6,464,255	24.4	0	1,819.0	1,741,227	78.7	0.4	3,501.7
IT per Worker									
Software Investment	EAE	2,569,390	27.6	0	169.6	1,003,509	53.0	0	229.9
Software Stock	EAE	2,569,390	83.8	0	3,139.1	1,003,509	162.6	0	4,847.2
Hardware Investment	BRN	6,464,255	172.9	0	795.7	1,741,227	202.0	0	784.5
Hardware Stock	BRN	6,464,255	478.7	0	2,516.4	1,741,227	675.1	34.3	3,243.4
IT per Unit of Capital									
Software Investment	EAE	2,092,313	21.8	0	1,178.7	901,948	31.0	0	1,449.4
Software Stock	EAE	2,413,294	4.0	0	29.2	972,268	5.4	0	26.5
Hardware Investment	BRN	4,584,180	108.6	0	991.0	1,443,204	106.0	0	1,488.4
Hardware Stock	BRN	5,826,631	38.9	0	127.4	1,645,389	35.0	1.9	103.3
IT per Unit of Cost									
Software Investment	EAE	2,569,383	0.7	0	4.2	1,003,509	1.2	0	5.3
Software Stock	EAE	2,569,390	0.6	0	3.1	1,003,509	1.1	0	3.6
Hardware Investment	BRN	6,464,210	3.7	0	27.7	1,741,225	4.1	0	28.8
Hardware Stock	BRN	6,464,254	2.3	0	7.8	1,741,227	3.0	0.2	7.2

Note: The units for all variables are thousand euros except for those involving intensity, share, or numbers. The units for the IT intensity of labor, capital, and cost are euros per worker, euros per thousand euros of capital, and euros per thousand euros of cost, respectively. Labor share, in percentage points, is defined as the sum of wage bill and payroll taxes divided by value-added. Stock measures are built using the Perpetual Inventory Method (PIM), imputing zero investment for missing data. The table reports hardware and capital inputs for all firms included at least once in the BRN files, and software inputs for all firms surveyed at least once by EAE. Data Appendix OA.2 in the main text describes the sources for each variable. The period is 1990-2007 for BRN + RSI data, 1995-2007 for BRN and EAE data. For the IT intensity of capital, the number of non missing observations is lower because of the higher occurrence of zeros in the denominator.

Table OA.17: Depreciation Rates, Benchmark

	Software	Hardware	Machinery & Inst.	Intangible	Other Capital
Manufacturing	0.315	0.138	0.108	0.232	0.046
Construction	0.315	0.154	0.139	0.261	0.061
TTFA	0.315	0.184	0.127	0.312	0.057
ICT	0.315	0.185	0.115	0.245	0.047
Prof Serv	0.315	0.197	0.144	0.224	0.097
Non-Market	0.315	0.270	0.143	0.246	0.029
Other Serv	0.315	0.212	0.138	0.271	0.054
Total	0.315	0.192	0.130	0.256	0.056

Note: Manufacturing includes the Utility sector. Non-Market sectors are Government, Health and Education. TTFA refers to the Trade, Transportation, and Food and Accommodation sectors. Source: EU KLEMS.

Table OA.17: Depreciation Rates, Alternative

	Software	Hardware	Machinery & Inst.	Intangible	Other Capital
Manufacturing	0.315	0.138	0.108	0.232	0.046
Construction	0.315	0.154	0.139	0.261	0.061
TTFA	0.315	0.184	0.127	0.312	0.057
ICT	0.315	0.185	0.115	0.245	0.047
Prof Serv	0.315	0.197	0.144	0.224	0.097
Non-Market	0.315	0.270	0.143	0.246	0.029
Other Serv	0.315	0.212	0.138	0.271	0.054
Total	0.315	0.192	0.130	0.256	0.056

Note: Manufacturing includes the Utility sector. Non-Market sectors are Government, Health and Education. TTFA refers to the Trade, Transportation, and Food and Accommodation sectors. Source: EU KLEMS.

Table OA.18: Representativeness of the Data, Benchmark

	Obs	Employment		Value Added		Investment	
		Total	Share	Total	Share	Total	Share
	(Nb)	(K Persons)	(%)	(Bn €)	(%)	(Bn €)	(%)
1995	446,663.0	9,030.9	74.5	414.2	64.8	60.7	53.9
1996	452,177.0	9,078.0	74.6	415.1	64.2	59.5	50.8
1997	487,450.0	9,400.5	76.5	431.9	64.6	61.7	52.7
1998	484,779.0	9,719.3	77.2	457.8	64.9	61.2	47.7
1999	489,318.0	9,988.8	77.1	479.8	65.3	65.5	46.0
2000	495,692.0	10,462.8	77.4	510.8	65.4	77.2	49.3
2001	484,046.0	10,678.4	76.8	526.1	64.3	71.7	43.1
2002	498,036.0	10,827.7	77.3	542.3	64.3	69.0	42.0
2003	498,224.0	10,770.9	77.1	547.8	63.5	62.4	38.2
2004	501,654.0	10,839.9	77.6	569.5	63.8	71.6	42.3
2005	503,158.0	10,951.6	78.1	590.0	64.5	78.8	44.0
2006	508,879.0	11,083.6	78.4	618.7	65.1	73.3	38.6
2007	498,415.0	11,383.8	79.2	639.4	64.0	76.5	36.8
Total	6,348,491.0	134,216.1	77.1	6,743.4	64.5	889.0	44.1

Note: The sample is all firms that appear at least once in the BRN, excluding trimmed observations.

Table OA.18: Representativeness of the Data, Alternative

	Obs	Employment		Value Added		Investment	
		Total	Share	Total	Share	Total	Share
	(Nb)	(K Persons)	(%)	(Bn €)	(%)	(Bn €)	(%)
1995	453,504.0	9,289.6	76.6	427.1	66.8	62.4	55.4
1996	459,412.0	9,329.9	76.6	427.1	66.1	60.4	51.6
1997	495,236.0	9,646.3	78.5	444.2	66.4	63.5	54.3
1998	492,818.0	9,977.5	79.2	471.8	66.8	64.1	50.0
1999	497,730.0	10,250.2	79.1	493.0	67.2	67.2	47.3
2000	504,544.0	10,724.5	79.3	524.1	67.1	81.1	51.8
2001	493,413.0	10,947.6	78.7	539.2	65.9	74.4	44.8
2002	508,017.0	11,098.8	79.3	555.3	65.9	71.2	43.4
2003	508,758.0	11,032.2	78.9	560.7	65.0	64.4	39.4
2004	513,069.0	11,104.0	79.5	583.0	65.4	74.0	43.7
2005	515,456.0	11,152.6	79.5	602.5	65.9	79.8	44.6
2006	522,245.0	11,286.2	79.8	630.1	66.3	75.5	39.8
2007	512,537.0	11,563.6	80.5	649.1	65.0	77.6	37.3
Total	6,476,739.0	137,402.9	78.9	6,907.2	66.1	915.8	45.5

Note: The sample is all firms that appear at least once in the BRN, excluding trimmed observations.

Table OA.19: Representativeness of the Raw Data, Benchmark

	Obs	Employment		Value Added		Investment	
		Total	Share	Total	Share	Total	Share
	(Nb)	(K Persons)	(%)	(Bn €)	(%)	(Bn €)	(%)
1995	574,255.0	9,673.1	79.8	474.8	74.3	90.5	80.4
1996	576,450.0	9,742.6	80.0	478.1	74.0	88.9	76.0
1997	628,223.0	10,104.0	82.2	498.8	74.5	124.0	105.9
1998	631,055.0	10,459.5	83.0	530.1	75.1	101.7	79.3
1999	633,187.0	10,754.6	83.0	556.6	75.8	107.6	75.6
2000	639,025.0	11,285.1	83.5	595.7	76.3	129.4	82.6
2001	621,175.0	11,579.2	83.3	612.2	74.9	134.7	81.0
2002	647,997.0	11,740.5	83.8	643.2	76.3	125.8	76.6
2003	652,554.0	11,669.0	83.5	651.9	75.6	133.3	81.6
2004	662,496.0	11,768.2	84.2	681.6	76.4	136.2	80.4
2005	668,505.0	11,866.1	84.6	712.9	77.9	161.1	90.0
2006	682,668.0	12,035.2	85.1	746.4	78.6	145.4	76.6
2007	672,028.0	12,507.5	87.1	774.4	77.6	225.2	108.2
Total	8,289,618.0	145,184.5	83.4	7,956.7	76.1	1,703.8	84.6

Note: The sample is all firms that appear at least once in the BRN, including trimmed observations.

Table OA.19: Representativeness of the Raw Data, Alternative

	Obs	Employment		Value Added		Investment	
		Total	Share	Total	Share	Total	Share
	(Nb)	(K Persons)	(%)	(Bn €)	(%)	(Bn €)	(%)
1995	585,085.0	9,964.1	82.2	490.1	76.7	93.3	82.8
1996	588,084.0	10,026.3	82.3	492.9	76.2	91.8	78.4
1997	641,153.0	10,382.8	84.4	514.5	76.9	128.1	109.5
1998	644,982.0	10,742.3	85.3	547.9	77.6	105.5	82.3
1999	648,181.0	11,041.0	85.2	573.5	78.1	111.2	78.2
2000	655,350.0	11,579.2	85.7	613.8	78.6	156.3	99.7
2001	638,751.0	11,923.3	85.7	633.1	77.4	139.3	83.8
2002	667,395.0	12,077.4	86.2	661.9	78.5	132.4	80.6
2003	673,641.0	12,000.5	85.8	671.9	77.9	137.9	84.4
2004	685,753.0	12,096.6	86.6	701.5	78.6	140.8	83.1
2005	694,313.0	12,136.1	86.6	732.7	80.1	166.6	93.0
2006	711,314.0	12,262.4	86.7	763.7	80.4	155.5	82.0
2007	701,453.0	12,684.3	88.3	795.8	79.7	234.3	112.6
Total	8,535,455.0	148,916.1	85.6	8,193.2	78.4	1,793.0	89.0

Note: The sample is all firms that appear at least once in the BRN, including trimmed observations.

Table OA.20: Representativeness of firms with zero IT capital, Benchmark

	Obs	Employment		Value Added		Investment	
		Total	Share	Total	Share	Total	Share
	(Nb)	(K Persons)	(%)	(Bn €)	(%)	(Bn €)	(%)
1995	317,355.0	2,383.7	19.7	85.9	13.4	10.1	9.0
1996	322,336.0	2,333.9	19.2	82.3	12.7	9.2	7.8
1997	353,330.0	2,434.8	19.8	85.2	12.7	9.8	8.4
1998	348,898.0	2,359.9	18.7	85.7	12.1	9.2	7.1
1999	351,236.0	2,374.1	18.3	88.7	12.1	10.0	7.0
2000	332,580.0	2,241.0	16.6	86.7	11.1	10.8	6.9
2001	296,821.0	1,999.6	14.4	79.8	9.8	8.1	4.9
2002	290,438.0	1,907.9	13.6	76.3	9.0	7.6	4.6
2003	238,693.0	1,458.4	10.4	58.9	6.8	4.8	2.9
2004	183,928.0	1,052.6	7.5	42.6	4.8	3.0	1.8
2005	150,005.0	847.1	6.0	35.3	3.9	2.2	1.2
2006	129,593.0	730.3	5.2	31.5	3.3	2.1	1.1
2007	104,119.0	719.8	5.0	28.6	2.9	2.1	1.0
Total	3,419,332.0	22,843.0	13.1	867.5	8.3	89.0	4.4

Note: The sample is all firms that appear at least once in the BRN with no software and hardware capital, excluding trimmed observations.

Table OA.20: Representativeness of firms with zero IT capital, Alternative

	Obs	Employment		Value Added		Investment	
		Total	Share	Total	Share	Total	Share
	(Nb)	(K Persons)	(%)	(Bn €)	(%)	(Bn €)	(%)
1995	321,129.0	2,401.4	19.8	86.8	13.6	10.3	9.2
1996	326,558.0	2,358.1	19.4	83.4	12.9	9.4	8.0
1997	358,072.0	2,463.9	20.0	86.5	12.9	10.6	9.1
1998	353,875.0	2,390.2	19.0	87.1	12.3	9.4	7.3
1999	356,530.0	2,408.8	18.6	90.3	12.3	10.2	7.2
2000	337,880.0	2,271.2	16.8	88.1	11.3	11.0	7.0
2001	302,135.0	2,032.2	14.6	81.4	10.0	8.4	5.0
2002	295,907.0	1,937.2	13.8	77.9	9.2	7.8	4.7
2003	243,677.0	1,481.8	10.6	60.2	7.0	5.0	3.0
2004	188,505.0	1,072.6	7.7	43.8	4.9	3.1	1.8
2005	154,500.0	865.0	6.2	39.9	4.4	2.3	1.3
2006	134,455.0	748.6	5.3	33.7	3.6	2.2	1.2
2007	109,113.0	714.9	5.0	29.9	3.0	2.2	1.1
Total	3,482,336.0	23,145.9	13.3	888.9	8.5	91.7	4.6

Note: The sample is all firms that appear at least once in the BRN with no software and hardware capital, excluding trimmed observations.

Table OA.21: Software Investment Summary Statistics (2006), Benchmark

2006	Number of Firms				Average values		Median values
	All	EAE	No software investment	Some software investment	EAE	Some software investment	Some software investment
0-5	227,281	12,313	12,295	18	0.01	4.39	4.00
5-10	155,707	16,416	16,185	231	0.08	5.82	3.00
10-20	84,629	17,065	15,952	1,113	0.54	8.35	4.00
20-50	55,548	36,701	30,427	6,272	1.91	11.20	5.00
50-100	13,481	10,439	7,521	2,918	5.68	20.31	8.00
100-250	8,884	7,244	4,512	2,732	14.07	37.30	15.00
250-500	2,527	2,143	1,146	997	42.99	92.40	31.00
500-1000	1,065	937	463	474	108.66	214.80	80.00
1000-2500	560	487	215	272	226.92	406.28	163.50
2500-5000	146	130	58	72	884.48	1596.99	788.00
+5000	96	76	32	44	5515.61	9526.95	743.50

Note: The first column denotes the class size in terms of BRN employment. Columns (2)-(5) count the number of firms for each of the four samples, in each size class: all firms in 2006, firms sampled in EAE in 2006, of which firms that declared zero or missing software investment, and firms that declared positive software investment. Columns (6)-(7) display average software investment for all firms in EAE in 2006 and those that declared positive investment. Column (8) displays median software investment for firms that declared positive software investment.

Table OA.21: Software Investment Summary Statistics (2006), Alternative

2006	Number of Firms				Average values		Median values
	All	EAE	No software investment	Some software investment	EAE	Some software investment	Some software investment
0-5	234,261	12,766	12,744	22	0.01	4.64	4.00
5-10	159,332	16,885	16,645	240	0.08	5.85	3.00
10-20	86,333	17,461	16,320	1,141	0.56	8.54	4.00
20-50	56,558	37,375	30,967	6,406	1.93	11.27	5.00
50-100	13,723	10,648	7,679	2,969	5.70	20.44	8.00
100-250	9,056	7,404	4,619	2,785	14.04	37.33	15.00
250-500	2,577	2,187	1,166	1,021	43.48	93.14	31.00
500-1000	1,094	963	472	491	114.04	223.68	81.00
1000-2500	573	496	217	279	247.65	440.26	167.00
2500-5000	151	133	59	74	866.95	1558.16	755.50
+5000	95	75	31	44	5589.15	9526.95	743.50

Note: The first column denote the class size in terms of BRN employment. Columns (2)-(5) count the number of firms for each of the four samples, in each class size : all firms in 1996, firms sampled in EAE in 1996, of which firms that declared zero or missing software investment, and firms that declared positive software investment. Columns (6)-(7) display average software investment for all firms in EAE in 1996 and those that declared positive investment. Column (8) displays median software investment for firms that declared positive software investment.

Table OA.22: Hardware Investment Summary Statistics (1996), Benchmark

1996	Number of Firms				Average values		Median values
	All	BRN	No hardware investment	Some hardware investment	BRN	Some hardware investment	Some hardware investment
0-5	214,156	170,345	168,931	1,307	0.02	2.94	1.52
5-10	135,664	122,186	119,216	2,855	0.10	4.32	2.13
10-20	58,170	56,465	53,882	2,515	0.30	6.87	3.05
20-50	48,896	48,786	43,840	4,878	1.63	17.00	7.01
50-100	11,392	11,392	8,368	2,976	8.41	33.90	15.55
100-250	7,200	7,200	3,390	3,769	33.34	67.39	31.56
250-500	2,173	2,173	479	1,684	115.87	149.86	74.85
500-1000	938	938	134	796	307.67	363.84	166.93
1000-2500	450	450	61	386	713.67	839.05	439.66
2500-5000	119	119	19	99	1832.74	2204.66	1061.35
+5000	55	55	9	46	12462.99	14901.40	2712.07

Note: The first column denotes the class size in terms of BRN employment. Columns (2)-(5) count the number of firms for each of the four samples, in each size class: all firms in 1996, firms sampled in BRN in 1996, of which firms that declared zero or missing hardware investment, and firms that declared positive hardware investment. Columns (6)-(7) display average hardware investment for all firms in BRN in 1996 and those that declared hardware investment. Column (8) displays median hardware investment for firms that declared positive hardware investment.

Table OA.22: Hardware Investment Summary Statistics (1996), Alternative

1996	Number of Firms				Average values		Median values
	All	BRN	No hardware investment	Some hardware investment	BRN	Some hardware investment	Some hardware investment
0-5	216,760	172,477	171,020	1,346	0.02	3.00	1.52
5-10	137,699	124,067	121,020	2,928	0.10	4.40	2.13
10-20	59,139	57,416	54,756	2,590	0.30	7.00	3.05
20-50	49,844	49,733	44,630	5,031	1.65	17.05	7.01
50-100	11,625	11,625	8,513	3,063	8.48	33.89	15.55
100-250	7,370	7,370	3,457	3,871	33.57	67.50	31.56
250-500	2,226	2,226	487	1,729	115.83	149.46	74.85
500-1000	971	971	140	823	302.69	358.36	164.04
1000-2500	467	467	63	401	709.54	833.11	445.46
2500-5000	122	122	18	103	1798.92	2132.36	1018.21
+5000	59	59	9	50	12237.89	14440.71	2851.94

Note: The first column denotes the class size in terms of BRN employment. Columns (2)-(5) count the number of firms for each of the four samples, in each size class: all firms in 1996, firms sampled in BRN in 1996, of which firms that declared zero or missing hardware investment, and firms that declared positive hardware investment. Columns (6)-(7) display average hardware investment for all firms in BRN in 1996 and those that declared hardware investment. Column (8) displays median hardware investment for firms that declared positive hardware investment.

Table OA.23: Hardware Investment Summary Statistics (2006), Benchmark

2006	Number of Firms				Average values		Median values
	All	BRN	No hardware investment	Some hardware investment	BRN	Some hardware investment	Some hardware investment
0-5	227,281	195,071	128,239	66,248	1.08	3.25	2.00
5-10	155,707	146,205	76,580	69,146	2.23	4.81	2.00
10-20	84,629	82,821	33,209	49,256	4.01	6.86	3.00
20-50	55,548	55,360	16,753	38,303	8.46	12.39	5.00
50-100	13,481	13,481	2,942	10,452	18.78	24.46	10.00
100-250	8,884	8,884	1,474	7,358	41.15	50.05	20.00
250-500	2,527	2,527	318	2,201	106.62	124.27	51.00
500-1000	1,065	1,065	137	924	206.65	239.18	113.00
1000-2500	560	560	68	487	586.07	701.21	295.00
2500-5000	146	146	15	130	1681.55	1892.44	950.50
+5000	96	96	16	80	5514.84	6617.81	1512.50

Note: The first column denotes the class size in terms of BRN employment. Columns (2)-(5) count the number of firms for each of the four samples, in each size class: all firms in 2006, firms sampled in BRN in 2006, of which firms that declared zero or missing hardware investment, and firms that declared positive hardware investment. Columns (6)-(7) display average hardware investment for all firms in BRN in 2006 and those that declared hardware investment. Column (8) displays median hardware investment for firms that declared positive hardware investment.

Table OA.23: Hardware Investment Summary Statistics (2006), Alternative

2006	Number of Firms				Average values		Median values
	All	BRN	No hardware investment	Some hardware investment	BRN	Some hardware investment	Some hardware investment
0-5	234,261	201,561	133,039	67,931	1.08	3.27	2.00
5-10	159,332	149,652	78,461	70,689	2.25	4.84	2.00
10-20	86,333	84,495	33,915	50,219	4.04	6.90	3.00
20-50	56,558	56,368	17,038	39,019	8.50	12.44	5.00
50-100	13,723	13,723	2,986	10,651	18.95	24.65	10.00
100-250	9,056	9,056	1,491	7,512	41.31	50.15	20.00
250-500	2,577	2,577	326	2,243	108.16	126.09	50.00
500-1000	1,094	1,094	141	948	210.80	244.24	113.00
1000-2500	573	573	67	501	581.66	691.78	295.00
2500-5000	151	151	16	134	1640.03	1851.90	923.00
+5000	95	95	16	79	5515.09	6632.08	1490.00

Note: The first column denotes the class size in terms of BRN employment. Columns (2)-(5) count the number of firms for each of the four samples, in each size class: all firms in 2006, firms sampled in BRN in 2006, of which firms that declared zero or missing hardware investment, and firms that declared positive hardware investment. Columns (6)-(7) display average hardware investment for all firms in BRN in 2006 and those that declared hardware investment. Column (8) displays median hardware investment for firms that declared positive hardware investment.

Table OA.24: Software Capital Summary Statistics (1996), Benchmark

1996	Number of Firms				Average values		Median values
	All	EAE	No software capital	Some software capital	EAE	Some software capital	Some software capital
0-5	214,156	59,273	58,928	345	0.02	3.29	0.00
5-10	135,664	59,310	57,308	2,002	0.04	1.09	0.00
10-20	58,170	42,307	37,241	5,066	0.26	2.17	0.00
20-50	48,896	44,941	28,553	16,388	2.81	7.69	1.69
50-100	11,392	10,533	4,848	5,685	9.86	18.26	6.45
100-250	7,200	6,644	2,586	4,058	24.37	39.90	14.73
250-500	2,173	2,061	690	1,371	68.29	102.66	50.80
500-1000	938	915	270	645	200.88	284.97	120.21
1000-2500	450	445	123	322	486.89	672.87	287.69
2500-5000	119	118	36	82	960.78	1382.59	872.82
+5000	55	52	14	38	15072.99	20626.20	2359.80

Note: The first column denotes the class size in terms of BRN employment. Columns (2)-(5) count the number of firms for each of the four samples, in each size class: all firms in 1996, firms sampled in EAE in 1996, firms with zero or missing software PIM capital, and firms with positive software PIM capital. Columns (6)-(7) display average software PIM capital for all firms in EAE in 1996 and those with positive software PIM capital. Column (8) displays median software PIM capital for firms with positive software PIM capital.

Table OA.24: Software Capital Summary Statistics (1996), Alternative

1996	Number of Firms				Average values		Median values
	All	EAE	No software capital	Some software capital	EAE	Some software capital	Some software capital
0-5	216,760	60,280	59,899	381	0.02	3.08	0.00
5-10	137,699	60,442	58,275	2,167	0.04	1.12	0.00
10-20	59,139	43,076	37,764	5,312	0.27	2.17	0.00
20-50	49,844	45,840	28,599	17,241	2.83	7.53	1.53
50-100	11,625	10,753	4,731	6,022	9.89	17.66	6.00
100-250	7,370	6,799	2,496	4,303	24.48	38.67	13.39
250-500	2,226	2,113	650	1,463	68.83	99.41	45.83
500-1000	971	947	247	700	199.69	270.15	112.94
1000-2500	467	462	115	347	482.95	643.00	266.31
2500-5000	122	121	32	89	948.53	1289.57	716.32
+5000	59	56	13	43	15299.43	19924.84	2167.62

Note: The first column denotes the class size in terms of BRN employment. Columns (2)-(5) count the number of firms for each of the four samples, in each size class: all firms in 1996, firms sampled in EAE in 1996, firms with zero or missing software PIM capital, and firms with positive software PIM capital. Columns (6)-(7) display average software PIM capital for all firms in EAE in 1996 and those with positive software PIM capital. Column (8) displays median software PIM capital for firms with positive software PIM capital.

Table OA.25: Software Capital Summary Statistics (2006), Benchmark

2006	Number of Firms				Average values		Median values
	All	EAE	No software capital	Some software capital	EAE	Some software capital	Some software capital
0-5	227,281	49,933	49,103	830	0.03	2.06	0.39
5-10	155,707	50,272	47,161	3,111	0.16	2.56	0.84
10-20	84,629	43,547	34,413	9,134	0.84	4.00	1.27
20-50	55,548	45,487	22,608	22,879	4.87	9.69	2.97
50-100	13,481	11,645	3,455	8,190	16.04	22.81	7.26
100-250	8,884	7,910	1,800	6,110	42.78	55.38	18.88
250-500	2,527	2,293	433	1,860	131.86	162.56	53.11
500-1000	1,065	1,005	146	859	326.25	381.70	145.01
1000-2500	560	540	88	452	708.58	846.54	351.96
2500-5000	146	142	25	117	2726.67	3309.29	1076.51
+5000	96	91	19	72	16645.92	21038.59	1750.17

Note: The first column denotes the class size in terms of BRN employment. Columns (2)-(5) count the number of firms for each of the four samples, in each size class: all firms in 2006, firms sampled in EAE in 2006, firms with zero or missing software PIM capital, and firms with positive software PIM capital. Columns (6)-(7) display average software PIM capital for all firms in EAE in 2006 and those with positive software PIM capital. Column (8) displays median software PIM capital for firms with positive software PIM capital.

Table OA.25: Software Capital Summary Statistics (2006), Alternative

2006	Number of Firms				Average values		Median values
	All	EAE	No software capital	Some software capital	EAE	Some software capital	Some software capital
0-5	234,261	51,576	50,590	986	0.05	2.77	0.48
5-10	159,332	51,595	48,279	3,316	0.18	2.78	0.84
10-20	86,333	44,517	35,064	9,453	0.87	4.10	1.29
20-50	56,558	46,337	22,971	23,366	4.93	9.78	2.99
50-100	13,723	11,873	3,530	8,343	16.25	23.13	7.29
100-250	9,056	8,073	1,827	6,246	42.84	55.37	18.72
250-500	2,577	2,337	435	1,902	134.10	164.77	54.15
500-1000	1,094	1,035	149	886	336.73	393.36	146.70
1000-2500	573	553	88	465	741.50	881.82	359.18
2500-5000	151	147	25	122	2739.91	3301.36	1103.10
+5000	95	90	17	73	16831.07	20750.64	1549.36

Note: The first column denotes the class size in terms of BRN employment. Columns (2)-(5) count the number of firms for each of the four samples, in each size class: all firms in 2006, firms sampled in EAE in 2006, firms with zero or missing software PIM capital, and firms with positive software PIM capital. Columns (6)-(7) display average software PIM capital for all firms in EAE in 2006 and those with positive software PIM capital. Column (8) displays median software PIM capital for firms with positive software PIM capital.

Table OA.26: Hardware Capital Summary Statistics (1996), Benchmark

1996	Number of Firms				Average values		Median values
	All	BRN	No hardware capital	Some hardware capital	BRN	Some hardware capital	Some hardware capital
0-5	214,156	214,156	186,564	27,592	0.10	0.75	0.09
5-10	135,664	135,664	100,976	34,688	0.35	1.38	0.17
10-20	58,170	58,170	37,740	20,430	1.17	3.32	0.36
20-50	48,896	48,896	24,282	24,614	6.13	12.18	1.23
50-100	11,392	11,392	3,995	7,397	31.57	48.62	9.31
100-250	7,200	7,200	1,537	5,663	121.75	154.80	76.17
250-500	2,173	2,173	170	2,003	416.31	451.65	278.52
500-1000	938	938	38	900	1032.41	1076.00	652.81
1000-2500	450	450	13	437	2582.70	2659.53	1777.07
2500-5000	119	119	3	116	5818.59	5969.07	3622.89
+5000	55	55	3	52	44769.33	47352.18	11771.77

Note: The first column denotes the class size in terms of BRN employment. Columns (2)-(5) count the number of firms for each of the four samples, in each size class: all firms in 1996, firms sampled in BRN in 1996, firms with zero or missing hardware PIM capital, and firms with positive hardware PIM capital. Columns (6)-(7) display average hardware PIM capital for all firms in BRN in 1996 and those with positive hardware PIM capital. Column (8) displays median hardware PIM capital for firms with positive hardware PIM capital.

Table OA.26: Hardware Capital Summary Statistics (1996), Alternative

1996	Number of Firms				Average values		Median values
	All	BRN	No hardware capital	Some hardware capital	BRN	Some hardware capital	Some hardware capital
0-5	216,760	216,760	188,639	28,121	0.10	0.80	0.09
5-10	137,699	137,699	102,274	35,425	0.38	1.46	0.17
10-20	59,139	59,139	38,258	20,881	1.21	3.43	0.36
20-50	49,844	49,844	24,699	25,145	6.25	12.39	1.23
50-100	11,625	11,625	4,051	7,574	31.56	48.44	9.39
100-250	7,370	7,370	1,568	5,802	124.18	157.73	76.20
250-500	2,226	2,226	173	2,053	421.79	457.34	278.47
500-1000	971	971	39	932	1041.04	1084.60	657.20
1000-2500	467	467	12	455	2620.11	2689.21	1860.21
2500-5000	122	122	2	120	5824.91	5921.99	3601.80
+5000	59	59	3	56	43853.19	46202.47	12415.01

Note: The first column denotes the class size in terms of BRN employment. Columns (2)-(5) count the number of firms for each of the four samples, in each size class: all firms in 1996, firms sampled in BRN in 1996, firms with zero or missing hardware PIM capital, and firms with positive hardware PIM capital. Columns (6)-(7) display average hardware PIM capital for all firms in BRN in 1996 and those with positive hardware PIM capital. Column (8) displays median hardware PIM capital for firms with positive hardware PIM capital.

Table OA.27: Hardware Capital Summary Statistics (2006), Benchmark

2006	Number of Firms				Average values		Median values
	All	BRN	No hardware capital	Some hardware capital	BRN	Some hardware capital	Some hardware capital
0-5	227,281	227,281	91,806	135,475	2.72	4.56	2.41
5-10	155,707	155,707	35,982	119,725	6.31	8.21	4.05
10-20	84,629	84,629	10,866	73,763	12.39	14.21	7.04
20-50	55,548	55,548	3,713	51,835	30.92	33.14	16.73
50-100	13,481	13,481	605	12,876	78.74	82.44	47.26
100-250	8,884	8,884	320	8,564	198.26	205.67	119.17
250-500	2,527	2,527	84	2,443	534.44	552.82	332.47
500-1000	1,065	1,065	28	1,037	1212.44	1245.18	699.05
1000-2500	560	560	21	539	2785.96	2894.50	1745.21
2500-5000	146	146	4	142	8070.12	8297.45	4535.24
+5000	96	96	3	93	39267.93	40534.64	11696.31

Note: The first column denotes the class size in terms of BRN employment. Columns (2)-(5) count the number of firms for each of the four samples, in each size class: all firms in 2006, firms sampled in BRN in 2006, firms with zero or missing hardware PIM capital, and firms with positive hardware PIM capital. Columns (6)-(7) display average hardware PIM capital for all firms in BRN in 2006 and those with positive hardware PIM capital. Column (8) displays median hardware PIM capital for firms with positive hardware PIM capital.

Table OA.27: Hardware Capital Summary Statistics (2006), Alternative

2006	Number of Firms				Average values		Median values
	All	BRN	No hardware capital	Some hardware capital	BRN	Some hardware capital	Some hardware capital
0-5	234,261	234,261	95,447	138,814	2.73	4.60	2.41
5-10	159,332	159,332	36,974	122,358	6.36	8.29	4.08
10-20	86,333	86,333	11,151	75,182	12.51	14.36	7.09
20-50	56,558	56,558	3,790	52,768	31.15	33.39	16.80
50-100	13,723	13,723	611	13,112	79.67	83.39	47.56
100-250	9,056	9,056	324	8,732	199.63	207.04	119.23
250-500	2,577	2,577	83	2,494	547.29	565.50	334.51
500-1000	1,094	1,094	28	1,066	1231.86	1264.22	712.87
1000-2500	573	573	21	552	2859.47	2968.25	1751.53
2500-5000	151	151	4	147	8072.99	8292.66	4666.16
+5000	95	95	3	92	39470.44	40757.52	11813.18

Note: The first column denotes the class size in terms of BRN employment. Columns (2)-(5) count the number of firms for each of the four samples, in each size class: all firms in 2006, firms sampled in BRN in 2006, firms with zero or missing hardware PIM capital, and firms with positive hardware PIM capital. Columns (6)-(7) display average hardware PIM capital for all firms in BRN in 2006 and those with positive hardware PIM capital. Column (8) displays median hardware PIM capital for firms with positive hardware PIM capital.

Table OA.28: Regressions of Log IT Per Employee on Log Firm Size, Clustered SEs, Benchmark

	Within-industry	
Panel 1: Software (Stock) per Employee		
Size (proxied by sales)	0.4034	
	(0.0269)	
Size (proxied by VA)		0.3933
		(0.0305)
Observations	557,728	557,793
Panel 1: Hardware (Stock) per Employee		
Size (proxied by sales)	0.6195	
	(0.0157)	
Size (proxied by VA)		0.5643
		(0.0172)
Observations	1,301,130	1,301,363

Note: In both panels the dependent variable is the logarithm of IT stock per employee. Standard errors are reported in brackets and are clustered at the 3-digit industry-level. The independent variable is the logarithm of firm size either proxied by sales or value added. The time period is 1995-2007. The sample is firms with at least 10 empoyees, in panel 1, sampled by EAE, and in panel 2, BRN firms. All columns include a full set of 3-digit industry classification fixed effects interacted with year fixed effects.

Table OA.28: Regressions of Log IT Per Employee on Log Firm Size, Clustered SEs, Alternative

	Within-industry	
Panel 1: Software (Stock) per Employee		
Size (proxied by sales)	0.4134	
	(0.0262)	
Size (proxied by VA)		0.3959
		(0.0290)
Observations	577,021	577,099
Panel 1: Hardware (Stock) per Employee		
Size (proxied by sales)	0.6186	
	(0.0159)	
Size (proxied by VA)		0.5629
		(0.0177)
Observations	1,327,762	1,328,026

Note: In both panels the dependent variable is the logarithm of IT stock per employee. Standard errors are reported in brackets and are clustered at the 3-digit industry-level. The independent variable is the logarithm of firm size either proxied by sales or value added. The time period is 1995-2007. The sample is firms with at least 10 empoyees, in panel 1, sampled by EAE, and in panel 2, BRN firms. All columns include a full set of 3-digit industry classification fixed effects interacted with year fixed effects.

Table OA.29: Estimation Results for Cobb-Douglas Production Functions ($\epsilon = 0, \sigma = 1$), Benchmark

		All Industries	Manufacturing
Non IT Capital Elasticity	γ_1	0.051	0.138
		(0.004)	(0.008)
Labor Elasticity	γ_2	0.772	0.699
		(0.010)	(0.018)
Software elasticity	γ_3	-0.034	0.026
		(0.010)	(0.010)
Hardware elasticity	γ_4	0.227	0.125
		(0.016)	(0.012)
Persistence of θ	$\rho_{\theta\theta}$	0.821	0.831
		(0.002)	(0.004)
Trend for θ	μ_θ	-0.004	0.001
		(0.001)	(0.001)
Shifter for θ	η_θ	0.667	0.560
		(0.011)	(0.016)
Observations	N	312981	150773

Note: Results of the estimation procedure with Cobb-Douglas production function $y_{it} = \gamma_1 k_{it} + \gamma_2 l_{it} + \gamma_3 s_{it} + \gamma_4 h_{it} + \widetilde{\theta}_{it}$ for the pooled sample of all firms, and for the pooled sample of manufacturing firms. Standard errors are reported in brackets.

Table OA.29: Estimation Results for Cobb-Douglas Production Functions ($\epsilon = 0, \sigma = 1$), Alternative

		All Industries	Manufacturing
Non IT Capital Elasticity	γ_1	0.052	0.130
		(0.005)	(0.008)
Labor Elasticity	γ_2	0.770	0.686
		(0.011)	(0.017)
Software elasticity	γ_3	-0.074	0.029
		(0.015)	(0.009)
Hardware elasticity	γ_4	0.272	0.134
		(0.021)	(0.011)
Persistence of θ	$\rho_{\theta\theta}$	0.822	0.828
		(0.002)	(0.004)
Trend for θ	μ_θ	-0.007	0.001
		(0.001)	(0.001)
Shifter for θ	η_θ	0.670	0.585
		(0.010)	(0.016)
Observations	N	315186	159066

Note: Results of the estimation procedure with Cobb-Douglas production function $y_{it} = \gamma_1 k_{it} + \gamma_2 l_{it} + \gamma_3 s_{it} + \gamma_4 h_{it} + \widetilde{\theta}_{it}$ for the pooled sample of all firms, and for the pooled sample of manufacturing firms. Standard errors are reported in brackets.

Table OA.30: Full Estimation Results by Industry, Benchmark

	ϵ	σ	γ	α	β	N
Food products	0.875	0.469	0.949	0.261	0.119	20,117
	(0.059)	(0.040)	(0.012)	(0.015)	(0.112)	
Textiles	0.704	0.241	0.883	0.127	0.269	9,986
	(0.055)	(0.064)	(0.028)	(0.025)	(0.091)	
Wood, paper, and printing	0.618	0.083	0.956	0.143	0.128	18,021
	(0.060)	(0.063)	(0.012)	(0.013)	(0.067)	
Chemicals	0.525	0.405	0.949	0.143	0.000	6,342
	(0.105)	(0.073)	(0.036)	(0.042)	(0.208)	
Pharmaceuticals	0.136	0.424	0.838	0.000	-0.722	1,560
	(0.407)	(0.140)	(0.107)	(0.107)	(0.511)	
Rubber and plastic products	0.595	0.389	0.971	0.217	-0.388	15,658
	(0.208)	(0.179)	(0.012)	(0.014)	(0.403)	
Basic metals	0.613	0.074	0.978	0.164	0.218	30,911
	(0.049)	(0.040)	(0.007)	(0.008)	(0.035)	
Computers and electronics	0.463	0.014	1.006	0.148	0.365	5,690
	(0.158)	(0.193)	(0.031)	(0.042)	(0.150)	
Electrical equipments	0.364	0.446	0.955	0.039	0.000	4,024
	(0.119)	(0.115)	(0.035)	(0.050)	(0.316)	
Machinery and equipments	0.359	0.096	0.973	0.132	0.141	12,139
	(0.067)	(0.119)	(0.011)	(0.013)	(0.100)	
Transport equipments	0.495	0.117	0.951	0.103	0.191	6,068
	(0.043)	(0.062)	(0.014)	(0.021)	(0.107)	
Other manufacturing products	0.846	0.147	0.916	0.056	0.402	18,228
	(0.298)	(0.254)	(0.014)	(0.012)	(0.109)	
Mining, energy, and utilities	0.644	0.443	0.985	0.318	0.113	6,018
	(0.087)	(0.075)	(0.023)	(0.019)	(0.174)	
Construction	1.793	0.587	0.911	0.089	0.895	28,200
	(0.239)	(0.035)	(0.008)	(0.007)	(0.040)	
Wholesale and retail trade	0.058	0.065	0.949	0.063	0.003	60,592
	(0.016)	(0.018)	(0.009)	(0.012)	(0.017)	
Transportation	0.965	0.040	0.960	0.058	0.884	20,161
	(0.062)	(0.038)	(0.013)	(0.012)	(0.018)	
Accommodation and food services	0.619	0.014	0.946	0.163	0.895	7,014
	(0.086)	(0.037)	(0.012)	(0.011)	(0.034)	
Publishing and motion pictures	0.108	0.407	0.979	0.053	-0.894	6,559
	(0.186)	(0.108)	(0.023)	(0.019)	(0.372)	
ICT	0.522	0.068	0.933	0.092	0.929	4,701
	(0.129)	(0.107)	(0.017)	(0.020)	(0.036)	
Legal, accounting, and engineering	0.352	0.029	0.938	0.081	0.164	7,973
	(0.145)	(0.202)	(0.028)	(0.023)	(0.100)	
Research	0.197	0.462	0.937	0.062	-0.409	3,920
	(0.265)	(0.158)	(0.037)	(0.024)	(0.426)	
Administrative and support	2.917	0.130	0.733	0.059	0.792	13,622
	(0.246)	(0.214)	(0.053)	(0.012)	(0.087)	

Note: Results of our estimation procedure across 22 industries of the market economy (level A38 of the NAF classification) in France. For details, see Section OA.5.9 of this online appendix. Standard errors are reported in brackets.

Table OA.30: Full Estimation Results by Industry, Alternative

	ϵ	σ	γ	α	β	N
Food products	0.500	0.244	0.967	0.235	0.257	20,813
	(0.201)	(0.227)	(0.013)	(0.015)	(0.143)	
Textiles	0.561	0.234	0.903	0.120	0.159	11,483
	(0.056)	(0.060)	(0.031)	(0.028)	(0.087)	
Wood, paper, and printing	0.710	0.196	0.951	0.139	0.000	18,736
	(0.283)	(0.287)	(0.011)	(0.012)	(0.245)	
Chemicals	0.183	0.153	0.975	0.146	0.001	6,834
	(0.067)	(0.267)	(0.022)	(0.023)	(0.210)	
Pharmaceuticals	0.704	0.243	0.691	0.593	0.797	1,886
	(0.158)	(0.288)	(0.179)	(0.413)	(0.370)	
Rubber and plastic products	0.346	0.120	0.982	0.225	0.000	16,987
	(0.086)	(0.163)	(0.011)	(0.013)	(0.140)	
Basic metals	0.611	0.101	0.977	0.178	0.144	30,833
	(0.219)	(0.259)	(0.008)	(0.009)	(0.140)	
Computers and electronics	0.460	0.014	0.994	0.141	0.386	5,900
	(0.041)	(0.094)	(0.024)	(0.033)	(0.093)	
Electrical equipments	0.565	0.510	0.922	0.033	0.001	4,289
	(0.111)	(0.088)	(0.027)	(0.039)	(0.291)	
Machinery and equipments	0.345	0.157	0.987	0.128	0.079	13,221
	(0.061)	(0.089)	(0.011)	(0.013)	(0.098)	
Transport equipments	0.464	0.098	0.966	0.153	0.174	5,445
	(0.111)	(0.189)	(0.019)	(0.029)	(0.164)	
Other manufacturing products	0.822	0.146	0.929	0.042	0.344	20,621
	(0.030)	(0.041)	(0.011)	(0.011)	(0.065)	
Mining, energy, and utilities	1.028	0.567	0.974	0.284	0.000	6,476
	(0.116)	(0.041)	(0.022)	(0.018)	(0.216)	
Construction	3.049	0.774	0.911	0.093	0.804	27,661
	(0.394)	(0.020)	(0.008)	(0.007)	(0.072)	
Wholesale and retail trade	0.050	0.057	0.965	0.009	0.029	54,636
	(0.017)	(0.012)	(0.010)	(0.014)	(0.012)	
Transportation	0.954	0.017	0.965	0.073	0.904	20,260
	(0.067)	(0.035)	(0.014)	(0.012)	(0.018)	
Accommodation and food services	0.554	0.014	0.958	0.179	0.915	7,229
	(0.067)	(0.048)	(0.011)	(0.010)	(0.036)	
Publishing and motion pictures	0.467	0.499	0.934	0.013	-0.971	6,649
	(0.133)	(0.071)	(0.024)	(0.022)	(0.495)	
ICT	0.076	0.128	0.934	0.268	0.167	3,700
	(0.067)	(0.074)	(0.047)	(0.048)	(0.122)	
Legal, accounting, and engineering	0.479	0.016	0.968	0.175	0.109	15,905
	(0.049)	(0.024)	(0.021)	(0.019)	(0.034)	
Research	0.352	0.325	0.930	0.027	0.219	4,450
	(0.436)	(0.164)	(0.042)	(0.028)	(0.150)	
Administrative and support	0.162	0.016	0.948	0.105	0.258	6,215
	(0.133)	(0.115)	(0.060)	(0.030)	(0.165)	

Note: Results of our estimation procedure across 22 industries of the market economy (level A38 of the NAF classification) in France. For details, see Section OA.5.9 of this online appendix. Standard errors are reported in brackets.

Table OA.31: Estimation Results by Industry, Linear Estimation, Benchmark

	ϵ	σ	γ	α	β	N
Food products	0.805	0.429	1.010	0.250	0.136	20,117
	(0.615)	(0.396)	(0.105)	(0.032)	(0.582)	
Textiles	0.491	0.291	1.018	0.052	-0.069	9,986
	(0.073)	(0.049)	(0.056)	(0.038)	(0.128)	
Wood, paper, and printing	0.647	0.115	0.992	0.148	0.093	18,021
	(0.391)	(0.484)	(0.240)	(0.045)	(0.456)	
Chemicals	0.557	0.554	1.000	0.206	-0.696	6,342
	(2.193)	(1.501)	(0.082)	(0.160)	(5.447)	
Pharmaceuticals	0.283	0.481	0.881	0.119	-0.423	1,560
	(0.407)	(0.452)	(0.094)	(0.189)	(0.911)	
Rubber and plastic products	0.830	0.370	1.023	0.203	0.031	15,658
	(0.085)	(0.117)	(0.047)	(0.024)	(0.294)	
Basic metals	0.615	0.043	1.010	0.155	0.266	30,911
	(0.150)	(0.176)	(0.005)	(0.011)	(0.102)	
Computers and electronics	0.439	-0.072	1.082	0.116	0.363	5,690
	(0.370)	(0.676)	(0.710)	(0.205)	(0.359)	
Electrical equipments	0.137	0.473	0.975	0.113	-0.448	4,024
	(0.290)	(0.583)	(0.042)	(0.065)	(1.540)	
Machinery and equipments	0.426	0.116	1.009	0.117	0.159	12,139
	(0.205)	(0.233)	(0.008)	(0.017)	(0.086)	
Transport equipments	0.509	0.078	0.994	0.119	0.315	6,068
	(0.047)	(0.089)	(0.109)	(0.030)	(0.164)	
Other manufacturing products	0.878	0.177	1.004	0.070	0.383	18,228
	(0.057)	(0.059)	(0.112)	(0.018)	(0.119)	
Mining, energy, and utilities	0.600	0.394	1.024	0.341	0.228	6,018
	(0.362)	(0.364)	(0.081)	(0.069)	(0.496)	
Construction	1.518	0.650	0.940	0.088	0.732	28,200
	(3.279)	(0.749)	(0.096)	(0.013)	(0.571)	
Wholesale and retail trade	0.132	0.189	0.969	0.060	-0.180	60,592
	(0.014)	(0.022)	(0.008)	(0.016)	(0.037)	
Transportation	0.502	-0.519	1.039	0.054	0.913	20,161
	(0.248)	(0.626)	(0.983)	(0.018)	(0.023)	
Accomodation and food services	0.274	-0.703	0.956	0.160	0.918	7,014
	(0.210)	(0.883)	(0.119)	(0.026)	(0.036)	
Publishing and motion pictures	0.705	0.470	0.941	0.061	-0.439	6,559
	(1.004)	(0.688)	(0.100)	(0.061)	(1.816)	
ICT	0.511	0.008	1.001	0.073	0.938	4,701
	(0.174)	(0.317)	(0.523)	(0.073)	(0.057)	
Legal, accounting, and engineering	0.335	-0.021	0.987	0.093	0.200	7,973
	(0.086)	(0.204)	(1.014)	(0.043)	(0.150)	
Research	1.142	0.638	0.952	0.072	0.087	3,920
	(2.997)	(0.970)	(0.302)	(0.041)	(2.561)	
Administrative and support	0.404	0.597	0.989	0.003	0.251	13,622
	(0.855)	(0.306)	(0.084)	(0.063)	(0.470)	

Note: Results of the third step of our estimation procedure across 22 industries of the market economy (level A38 of the NAF classification) in France, with the log-linearized production function. For details, see Section OA.5.9 of this online appendix. Standard errors are reported in brackets.

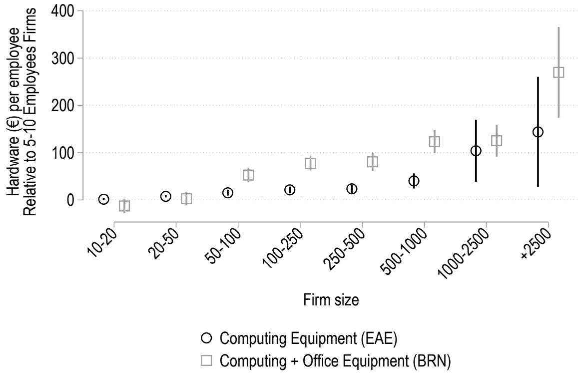
Table OA.31: Estimation Results by Industry, Linear Estimation, Alternative

	ϵ	σ	γ	α	β	N
Food products	0.570	0.300	1.021	0.237	0.232	20,813
	(0.023)	(0.097)	(0.048)	(0.022)	(0.160)	
Textiles	0.361	0.285	1.016	0.067	-0.124	11,483
	(0.219)	(0.112)	(0.057)	(0.040)	(0.174)	
Wood, paper, and printing	0.926	0.316	0.998	0.153	-0.042	18,736
	(0.070)	(0.048)	(0.026)	(0.017)	(0.132)	
Chemicals	0.237	0.321	0.983	0.142	-0.160	6,834
	(0.205)	(0.463)	(0.044)	(0.040)	(0.748)	
Pharmaceuticals	0.432	0.520	0.872	0.012	-0.328	1,886
	(0.453)	(0.454)	(0.079)	(0.178)	(0.919)	
Rubber and plastic products	0.409	0.146	1.014	0.201	0.021	16,987
	(0.416)	(0.692)	(0.166)	(0.043)	(0.621)	
Basic metals	0.586	-0.007	1.008	0.231	0.223	30,833
	(0.101)	(0.124)	(0.056)	(0.013)	(0.091)	
Computers and electronics	0.405	-0.123	1.062	0.098	0.379	5,900
	(0.418)	(0.829)	(0.371)	(0.064)	(0.488)	
Electrical equipments	0.401	0.479	0.980	0.109	-0.048	4,289
	(1.631)	(1.678)	(0.211)	(0.093)	(3.082)	
Machinery and equipments	0.426	0.175	1.023	0.117	0.136	13,221
	(0.391)	(0.711)	(0.183)	(0.049)	(0.666)	
Transport equipments	0.495	0.049	1.008	0.148	0.288	5,445
	(0.071)	(0.123)	(0.236)	(0.041)	(0.210)	
Other manufacturing products	0.816	0.150	1.017	0.072	0.311	20,621
	(0.074)	(0.044)	(0.115)	(0.015)	(0.107)	
Mining, energy, and utilities	0.891	0.529	1.016	0.324	0.025	6,476
	(0.684)	(0.370)	(0.081)	(0.059)	(0.792)	
Construction	1.165	0.822	0.917	0.089	0.482	27,661
	(1.847)	(0.400)	(0.023)	(0.019)	(1.323)	
Wholesale and retail trade	0.041	0.114	0.970	0.014	-0.041	54,636
	(0.018)	(0.014)	(0.009)	(0.021)	(0.022)	
Transportation	0.476	-0.409	1.051	0.066	0.908	20,260
	(0.178)	(0.511)	(0.807)	(0.037)	(0.023)	
Publishing and motion pictures	0.745	0.502	0.910	0.033	-0.655	6,649
	(1.304)	(0.841)	(0.063)	(0.051)	(2.790)	
ICT	0.006	0.495	0.971	0.195	-0.443	3,700
	(0.102)	(0.459)	(0.037)	(0.055)	(1.419)	
Legal, accounting, and engineering	0.433	-0.227	1.062	0.212	0.299	15,905
	(0.039)	(0.066)	(0.049)	(0.046)	(0.043)	
Research	0.853	0.555	0.958	0.009	0.221	4,450
	(1.022)	(0.603)	(0.314)	(0.094)	(1.261)	
Administrative and support	0.120	-0.113	0.962	0.068	0.242	6,215
	(0.106)	(0.596)	(0.055)	(0.052)	(0.448)	

Note: Results of the third step of our estimation procedure across 21 industries of the market economy (level A38 of the NAF classification) in France, with the log-linearized production function. For details, see Section OA.5.9 of this online appendix. Standard errors are reported in brackets.

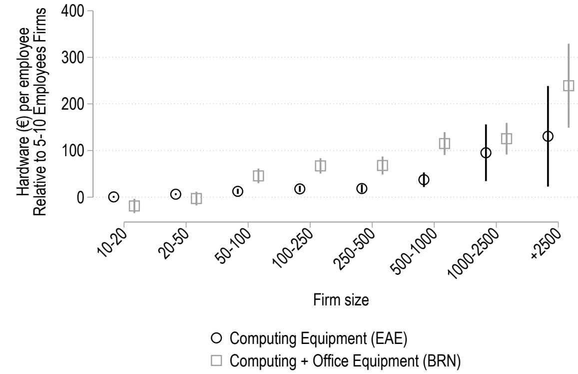
OA.8 Additional Figures

Figure OA.9: Cross-sectional Relationship Between Size and Computing relative to Total or Hardware Investment, Benchmark



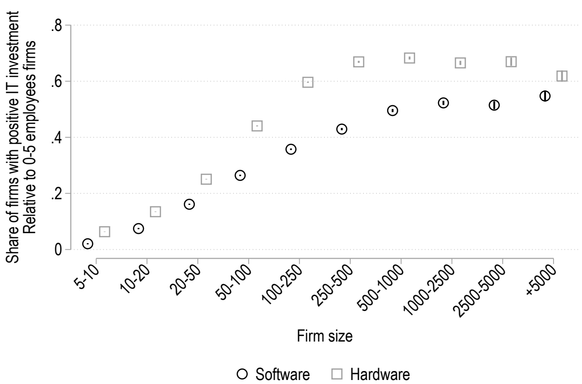
Note: This figure reports the conditional average of EAE computing investment, excluding non-IT office furniture, and BRN hardware investment, including non-IT office furniture, relative to the number of employees, by firm size. Averages are conditional on a set of flexible fixed effects constructed from the interaction of 3-digit industry codes and time dummies, and a full set of cohorts fixed effect (pre 1980, 1980-1993, 1993-1995 ... 2005-2007) and normalized age fixed effects. The sample includes all firms sampled in EAE for which that question was asked, 90% of which are in the AgriFood industry. The bands around the estimates show the 90% confidence intervals.

Figure OA.9: Cross-sectional Relationship Between Size and Computing relative to Total or Hardware Investment,Alternative



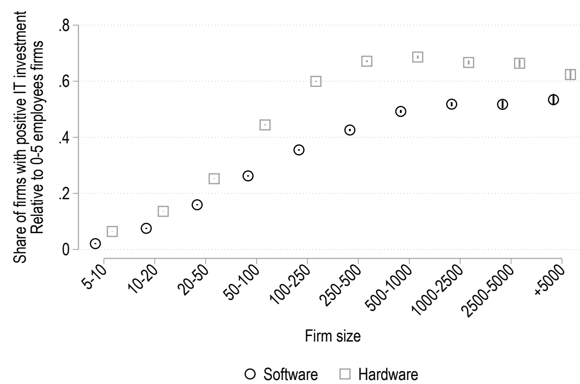
Note: This figure reports the conditional average of EAE computing investment, excluding non-IT office furniture, and BRN hardware investment, including non-IT office furniture, relative to the number of employees, by firm size. Averages are conditional on a set of flexible fixed effects constructed from the interaction of 3-digit industry codes and time dummies, and a full set of cohorts fixed effect (pre 1980, 1980-1993, 1993-1995 ... 2005-2007) and normalized age fixed effects. The sample includes all firms sampled in EAE for which that question was asked, 90% of which are in the AgriFood industry. The bands around the estimates show the 90% confidence intervals.

Figure OA.10: Cross-sectional Relationship Between Extensive Margin of Investment and Firm Size, Benchmark



Note: This figure reports the proportion of firms with positive IT investment by firm size. Proportions are conditional on a set of flexible fixed effects constructed from the interaction of 4-digit industry codes and time dummies.

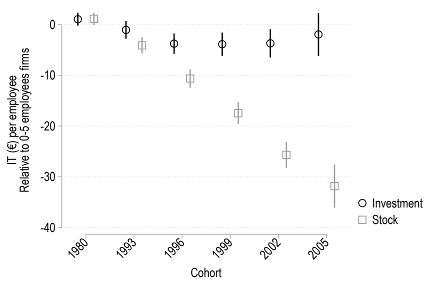
Figure OA.10: Cross-sectional Relationship Between Extensive Margin of Investment and Firm Size, Alternative



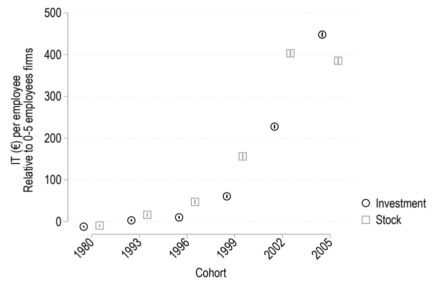
Note: This figure reports the proportion of firms with positive IT investment by firm size. Proportions are conditional on a set of flexible fixed effects constructed from the interaction of 4-digit industry codes and time dummies.

Figure OA.11: Cross-sectional Relationship Between IT and Firm Cohort, Benchmark

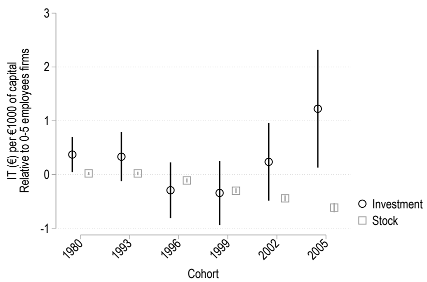
(a) Software per Unit of Labor



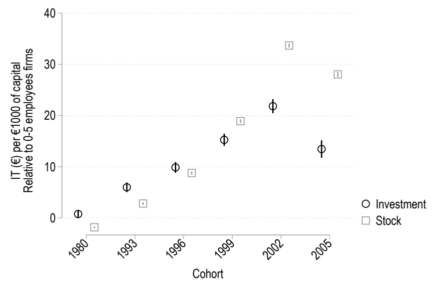
(b) Hardware per Unit of Labor



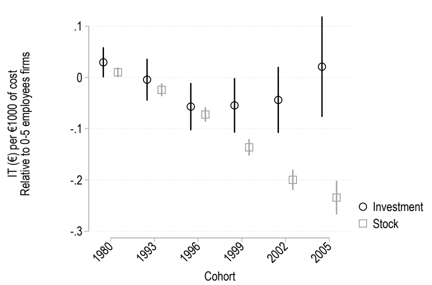
(c) Software per Unit of Capital



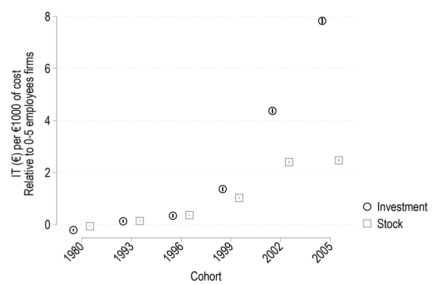
(d) Hardware per Unit of Capital



(e) Software per Unit of Costs



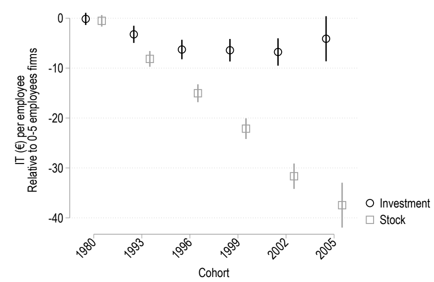
(f) Hardware per Unit of Costs



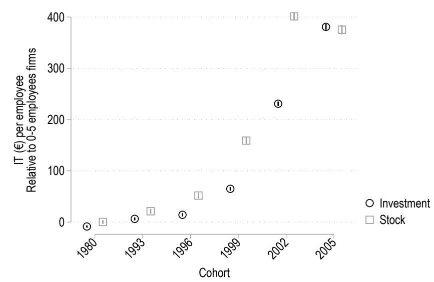
Note: This figure reports the average of relative IT demand by firm cohort. Averages are conditional on a set of flexible fixed effects constructed from the interaction of 3-digit industry codes and time dummies, and a full set of cohorts fixed effect (pre 1980, 1980-1993, 1993-1995 ... 2005-2007) and normalized age fixed effects. In the case of software, the sample includes all firms that were sampled in EAE (that year for investment, at least once for capital). In the case of hardware, the sample includes all firms that reported hardware investment lower than 0.99 times total investment. The units for the IT intensity of labor, capital, and cost are euros per worker, euros per thousand euros of capital, and euros per thousand euros of cost, respectively. Imputed values of the "investment" measures are dropped from the analysis. The bands around the estimates show the 90% confidence intervals.

Figure OA.11: Cross-sectional Relationship Between IT and Firm Cohort, Alternative

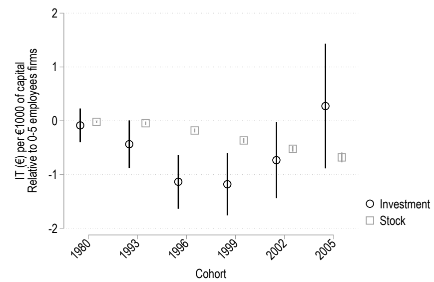
(a) Software per Unit of Labor



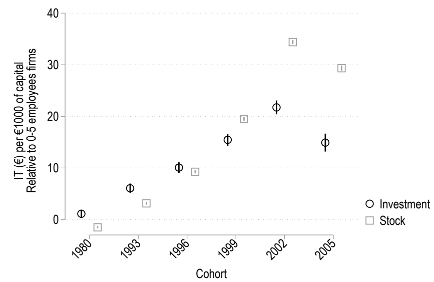
(b) Hardware per Unit of Labor



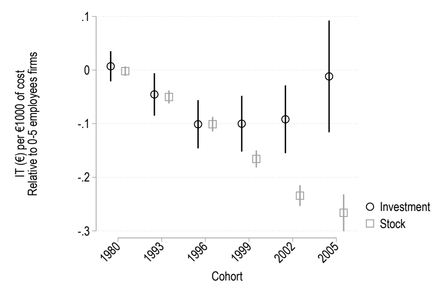
(c) Software per Unit of Capital



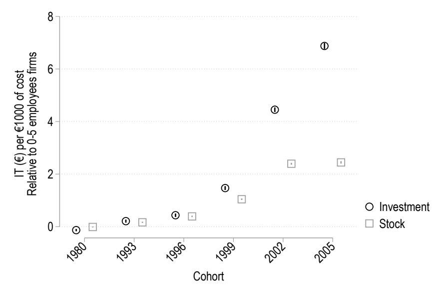
(d) Hardware per Unit of Capital



(e) Software per Unit of Costs



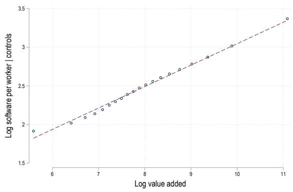
(f) Hardware per Unit of Costs



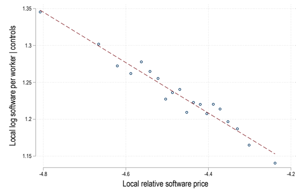
Note: This figure reports the average of relative IT demand by firm cohort. Averages are conditional on a set of flexible fixed effects constructed from the interaction of 3-digit industry codes and time dummies, and a full set of cohorts fixed effect (pre 1980, 1980-1993, 1993-1995 ... 2005-2007) and normalized age fixed effects. In the case of software, the sample includes all firms that were sampled in EAE (that year for investment, at least once for capital). In the case of hardware, the sample includes all firms that reported hardware investment lower than 0.99 times total investment. The units for the IT intensity of labor, capital, and cost are euros per worker, euros per thousand euros of capital, and euros per thousand euros of cost, respectively. Imputed values of the "investment" measures are dropped from the analysis. The bands around the estimates show the 90% confidence intervals.

Figure OA.12: Identification of Scale-Dependence (ϵ) and Elasticity of Substitution (σ), Benchmark

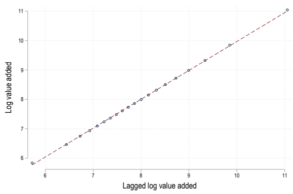
(a) OLS, ϵ



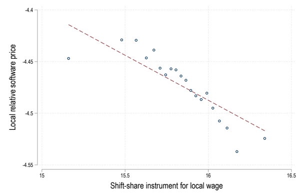
(b) OLS, σ



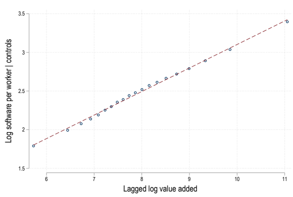
(c) First Stage, ϵ



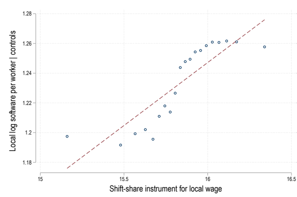
(d) First Stage, σ



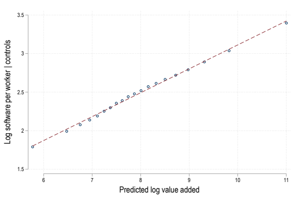
(e) Reduced Form, ϵ



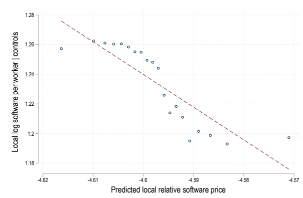
(f) Reduced Form, σ



(g) Second Stage, ϵ



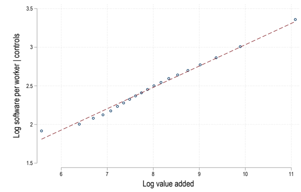
(h) Second Stage, σ



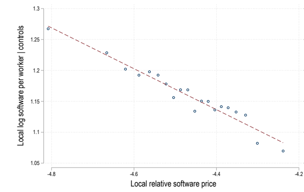
Note: This figure reports the relationships in the data between software stock per worker (minus the controls), and the logarithms of value added and relative price of software, and their respective instruments, the logarithm of lagged value added and the shift-share instrument for local labor demand. In the first and in the second columns, OLS corresponds to a simple regression of software stock per worker (minus the controls) on RHS (corresponding to Equations OA.5.7 and OA.5.6, respectively), first stage to a regression of RHS on its instrument, reduced form to a regression of software stock per worker (minus the controls) on the instrument, and second stage to a regression of software stock per worker (minus the controls) on the predicted value of RHS from the first stage. The 95% confidence intervals drawn correspond to prediction intervals, including both the standard error around the slope and the variance of residuals. For the identification of σ, firms' outcomes are averaged at the local × year level and regressions are weighted by the number of firms at each location × year. The sample of firms corresponds to the estimation results reported in Table 2 (all industries).

Figure OA.12: Identification of Scale-Dependence (ϵ) and Elasticity of Substitution (σ), Alternative

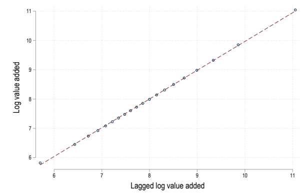
(a) OLS, ϵ



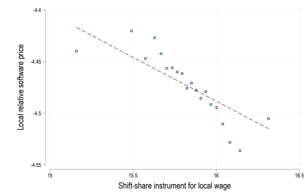
(b) OLS, σ



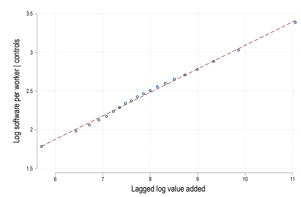
(c) First Stage, ϵ



(d) First Stage, σ

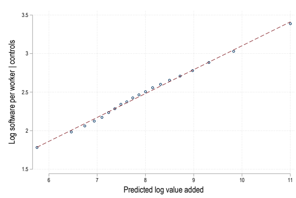


(e) Reduced Form, ϵ

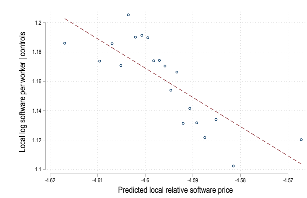


(f) Reduced Form, σ

(g) Second Stage, ϵ



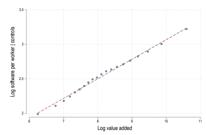
(h) Second Stage, σ



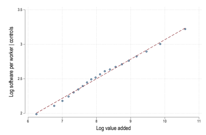
Note: This figure reports the relationships in the data between software stock per worker (minus the controls), and the logarithms of value added and relative price of software, and their respective instruments, the logarithm of lagged value added and the shift-share instrument for local labor demand. In the first and in the second columns, OLS corresponds to a simple regression of software stock per worker (minus the controls) on RHS (corresponding to Equations OA.5.7 and OA.5.6, respectively), first stage to a regression of RHS on its instrument, reduced form to a regression of software stock per worker (minus the controls) on the instrument, and second stage to a regression of software stock per worker (minus the controls) on the predicted value of RHS from the first stage. The 95% confidence intervals drawn correspond to prediction intervals, including both the standard error around the slope and the variance of residuals. For the identification of σ, firms' outcomes are averaged at the local × year level and regressions are weighted by the number of firms at each location × year. The sample of firms corresponds to the estimation results reported in Table 2 (all industries).

Figure OA.13: Structural Identification of Scale-dependence (ϵ) and Elasticity of Substitution (σ), Exporting Firms, Benchmark

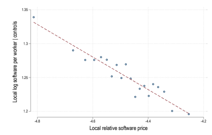
(a) OLS, ϵ, lagged IV



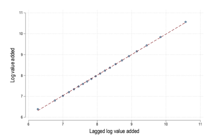
(b) OLS, ϵ, export IV



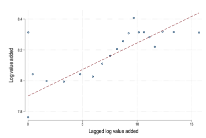
(c) OLS, σ



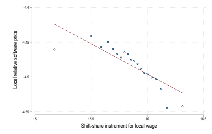
(d) First Stage, ϵ, lagged IV



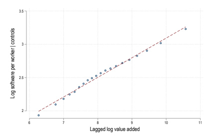
(e) First Stage, ϵ, export IV



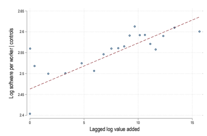
(f) First Stage, σ



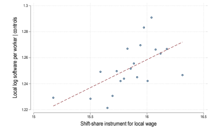
(g) Reduced Form, ϵ, lagged IV



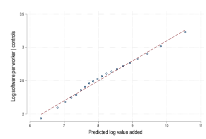
(h) Reduced Form, ϵ, export IV



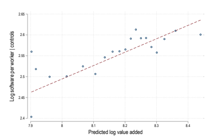
(i) Reduced Form, σ



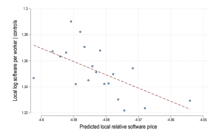
(j) Second Stage, ϵ, lagged IV



(k) Second Stage, ϵ, export IV



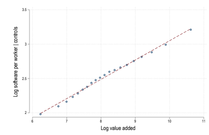
(l) Second Stage, σ



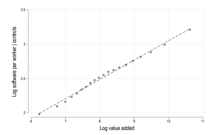
Note: This figure reports the relationships in the data between software stock per worker (minus the controls), and the logarithms of value added and relative price of software, and their respective instruments. In the first colmun, the logarithm of value added is instrumented by lagged logarithmn valued added and in the second by the export demand shock. In the third column, relative price of software is instrumented by the shift-share instrument for local labor demand. In all columns, OLS corresponds to a simple regression of software stock per worker (minus the controls) on RHS (corresponding to Equations OA.5.7 and OA.5.6, respectively), first stage to a regression of RHS on its instrument, reduced form to a regression of software stock per worker (minus the controls) on the instrument, and second stage to a regression of software stock per worker (minus the controls) on the predicted value of RHS from the first stage. The 95% confidence intervals drawn correspond to prediction intervals, including both the standard error around the slope and the variance of residuals. For the identification of σ, firms' outcomes are averaged at the local $\times$ year level and regressions are weighted by the number of firms at each location $\times$ year. The sample, exporting firms, is narrower than in the estimation results reported in Table 2.

Figure OA.13: Structural Identification of Scale-dependence (ϵ) and Elasticity of Substitution (σ), Exporting Firms, Alternative

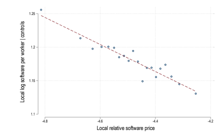
(a) OLS, ϵ, lagged IV



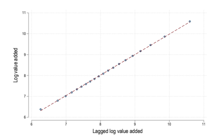
(b) OLS, ϵ, export IV



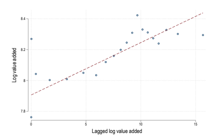
(c) OLS, σ



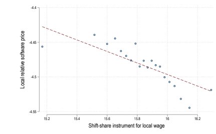
(d) First Stage, ϵ, lagged IV



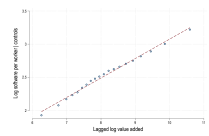
(e) First Stage, ϵ, export IV



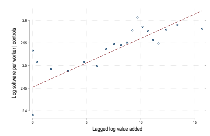
(f) First Stage, σ



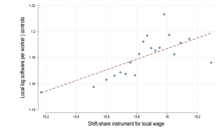
(g) Reduced Form, ϵ, lagged IV



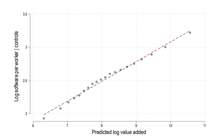
(h) Reduced Form, ϵ, export IV



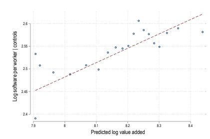
(i) Reduced Form, σ



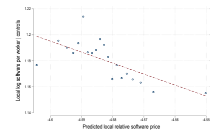
(j) Second Stage, ϵ, lagged IV



(k) Second Stage, ϵ, export IV

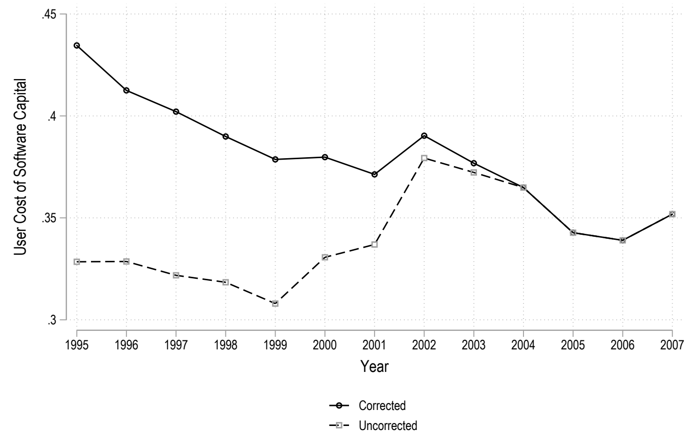


(l) Second Stage, σ



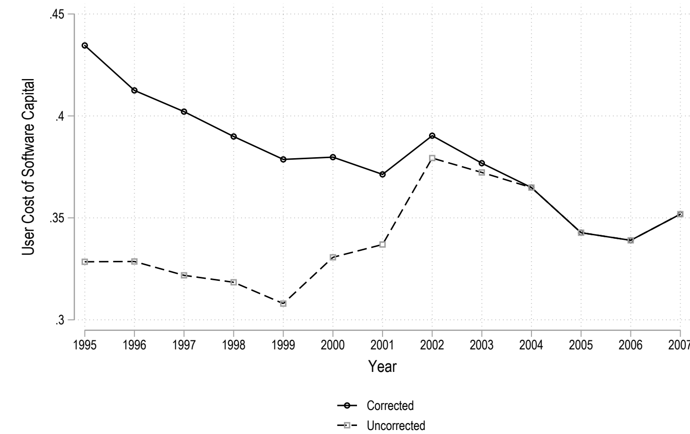
Note: This figure reports the relationships in the data between software stock per worker (minus the controls), and the logarithms of value added and relative price of software, and their respective instruments. In the first colmun, the logarithm of value added is instrumented by lagged logarithmn valued added and in the second by the export demand shock. In the third column, relative price of software is instrumented by the shift-share instrument for local labor demand. In all columns, OLS corresponds to a simple regression of software stock per worker (minus the controls) on RHS (corresponding to Equations OA.5.7 and OA.5.6, respectively), first stage to a regression of RHS on its instrument, reduced form to a regression of software stock per worker (minus the controls) on the instrument, and second stage to a regression of software stock per worker (minus the controls) on the predicted value of RHS from the first stage. The 95% confidence intervals drawn correspond to prediction intervals, including both the standard error around the slope and the variance of residuals. For the identification of σ, firms' outcomes are averaged at the local $\times$ year level and regressions are weighted by the number of firms at each location $\times$ year. The sample, exporting firms, is narrower than in the estimation results reported in Table 2.

Figure OA.14: Rental Price of Software, Benchmark



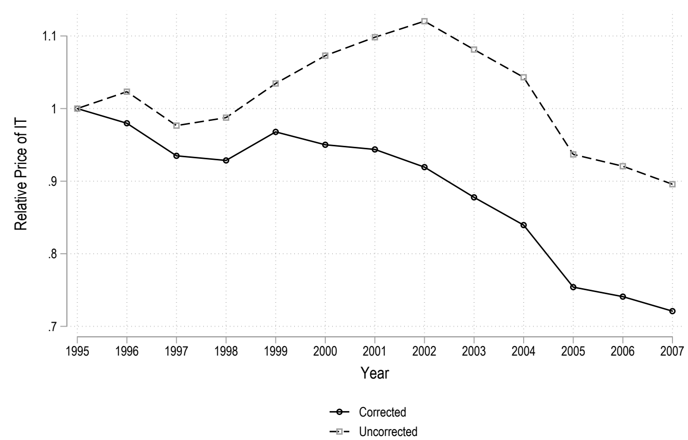
Note: This figure presents the value of the user cost of software capital with and without the additional quality adjustment to the INSEE series discussed in Section OA.2.2 (page 19). The unadjusted measure directly uses the price of software investment reported by INSEE National Accounts. The adjusted measure assumes that the price of software investment before 2002 followed the same trend as from 2002 to 2014.

Figure OA.14: Rental Price of Software, Alternative



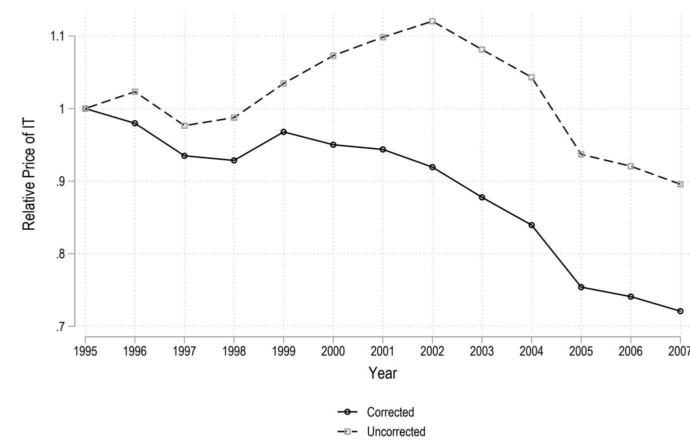
Note: This figure presents the value of the user cost of software capital with and without the additional quality adjustment to the INSEE series discussed in Section OA.2.2 (page 19). The unadjusted measure directly uses the price of software investment reported by INSEE National Accounts. The adjusted measure assumes that the price of software investment before 2002 followed the same trend as from 2002 to 2014.

Figure OA.15: Relative Price of IT Bundle to non-IT Bundle, Benchmark



Note: This figure presents the value of the relative price of the bundle of IT inputs to the bundle of non-IT inputs with and without the additional quality adjustment to the INSEE series for the price of software discussed in Section OA.2.2 (page 19). The unadjusted measure directly uses the price of software investment reported by INSEE National Accounts. The adjusted measure assumes that the price of software investment before 2002 followed the same trend as from 2002 to 2014.

Figure OA.15: Relative Price of IT Bundle to non-IT Bundle, Alternative



Note: This figure presents the value of the relative price of the bundle of IT inputs to the bundle of non-IT inputs with and without the additional quality adjustment to the INSEE series for the price of software discussed in Section OA.2.2 (page 19). The unadjusted measure directly uses the price of software investment reported by INSEE National Accounts. The adjusted measure assumes that the price of software investment before 2002 followed the same trend as from 2002 to 2014.

References

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