Online Appendix to

Decomposing Structural Change*

Jaime Alonso-Carrera [a]
Departamento de Fundamentos del Análisis Económico
Universidade de Vigo

María Jesús Freire-Serén [b]
Departamento de Fundamentos del Análisis Económico and GRiEE
Universidade de Vigo

Xavier Raurich [c]
Departament d'Economia
Universitat de Barcelona

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[a] Postal address: Universidade de Vigo, Facultad de Ciencias Económicas y Empresariales, Campus As Lagoas-Marcosende, 36310 Vigo (Spain). Phone: (34)986813516. E-mail: jalonso@uvigo.es

[b] Postal address: Universidade de Vigo, Facultad de Ciencias Económicas y Empresariales, Campus As Lagoas-Marcosende, 36310 Vigo (Spain). Phone: (34)986812524. E-mail: mjfreire@uvigo.es

[c] Postal address: Universitat de Barcelona, Facultat d'Economia i Empresa, Avinguda Diagonal 696, 08034 Barcelona (Spain). Phone: (34)934024333. E-mail: xavier.raurich@ub.edu

A. Properties and constraints of consumption demand

The price elasticity of the Marshallian demand of good i with respect to the price of good j is given by

$$\eta_{ij} = \left[\frac{\partial C^i(p,e)}{\partial p_j} \right] \left[\frac{p_j}{C^i(p,e)} \right], \tag{A.1}$$

whereas the income elasticity of this demand is

$$\mu_i = \left[\frac{\partial C^i(p,e)}{\partial e} \right] \left[\frac{e}{C^i(p,e)} \right]. \tag{A.2}$$

Since the demand system satisfies the budget constraint (2.9), we obtain the following properties of this system. First, we obtain, from deriving (2.9) with respect to expenditure, and after some algebra, that

$$\sum_{i=1}^{m} \mu_i x_i = 1, \tag{A.3}$$

which is the *Engel Aggregation Condition*, and where x_i is the expenditure share of the good produced in sector i, i.e., $x_i = p_i c_i / e$. In addition, we also obtain from the derivative of (2.9) with respect to price p_j, and after some algebra, that

$$x_j + \sum_{i=1}^{m} \eta_{ij} x_i = 0, \tag{A.4}$$

which is the *Cournot Aggregation Condition.* Finally, the demand theory states that demand functions are linearly homogeneous in prices and expenditure, so that the demand system must also satisfy the following *Homogeneity Condition*:

$$\mu_i + \sum_{j=1}^{m} \eta_{ij} = 0, \tag{A.5}$$

for all $i = 1, 2, ..., m$. The price elasticities (A.1) and the income elasticities (A.2) of the demand, together with the conditions (A.3), (A.4) and (A.5), fully characterize the optimal response of the sectoral composition of consumption to changes in economic conditions.

We now proceed to decompose the price effect into the substitution effect and the income effect. To see this, we use the Slutsky equation to show that the price-elasticities of the Marshallian demand are given by

$$\eta_{ij} = \eta_{ij}^* - x_j \mu_i, \tag{A.6}$$

where η_{ij}^* denotes the Hicks-Allen elasticity of substitution, i.e., the price elasticity of the compensated demand of good i, which we denote by $h^i(p,v)$, where v is the level of utility. That is,

$$\eta_{ij}^* = \frac{\partial h^i(p,v)}{\partial p_j} \frac{p_j}{h^i(p,v)}. \tag{A.7}$$

Equation (A.6) decomposes the effect of a change in the price of good j on the demand of good i into:

1. The *Hicks' substitution effect* given by η^*_{ij}. The variation of the demand of good i when consumers are compensated to maintain the same purchasing power as before the change in the price of good j, p_j.

2. The *Hicks' income effect* given by $x_j \mu_i$. The variation in the demand of good i that would be derived from the observed change in the purchasing power if the prices will not change at all.

The Hicks-Allen elasticity is then a measure of the net substitutability between consumption goods. However, this elasticity is not usually employed in the literature because it is not symmetric, i.e., η^*_{ik} may differ from η^*_{ki}. This happens even when the cross substitution effects are symmetric, i.e.,

$$\frac{\partial h^i (p, v)}{\partial p_k} = \frac{\partial h^k (p, v)}{\partial p_i}.$$

The literature uses others elasticities of substitution that are symmetric. In particular, a more useful measure of the substitution effect is the Allen-Uzawa elasticity of substitution that is given by

$$\sigma_{ij} = \frac{E (p, v) E_{ij} (p, v)}{E_i (p, v) E_j (p, v)}, \tag{A.8}$$

where $E (p, v)$ is the expenditure function given by

$$E (p, v) = \min_{c_i \in \Omega} \sum_{i=1}^{m} p_i c_i,$$

with

$$\Omega = \left\{ (c_1, ..., c_m) \in \mathbb{R}^m_+ : v(c_1, ..., c_m) \geq v \right\},$$

and where $E_i (p, v)$ is the derivative of $E (p, v)$ with respect to p_i and $E_{ij} (p, v)$ is the derivative of $E_i (p, v)$ with respect to p_j. One interesting property of this Allen-Uzawa elasticity is its relation with the Hicks-Allen elasticity, which is given by

$$\sigma_{ij} = \frac{\eta^*_{ij}}{x_j}. \tag{A.9}$$

Therefore, by substituting (A.9) into (A.6), we can rewrite the price elasticity of the Marshallian demand η_{ij} as follows

$$\eta_{ij} = x_j (\sigma_{ij} - \mu_i).$$

B. Revisiting the related literature

We apply our general analysis in the paper to those models of structural change commonly used by the literature. These models assume particular functional forms for preferences and technologies. In this section, we compute the income elasticities, the Allen-Uzawa elasticities, the sectoral capital income shares and the elasticities of substitution between production factors for these particular functional forms. We will focus on the following models in which structural change is based: (a) on non-homothetic preferences, introduced by Kongsamunt et al. (2001); (b) on biased technological progress, considered by Ngai and Pissarides (2007); (c) on capital deepening, proposed by Acemoglu and Guerrieri (2008); (d) on sectoral differences in capital-labor substitution, considered by Alvarez-Cuadrado et al. (2017); and (e) on long-run income and price effects of structural change, introduced by Comin et al. (2021). We next analyze each of these proposals.

B.1. Structural change based on non-homothetic preferences

An important thesis explaining the observed structural change is based on the sectoral differences in the response of the demand to the growth of income.[1] Let us illustrate the mechanics of this proposal. As in Kongsamunt et al. (2001), we consider a model where production functions are identical in all sectors, i.e., $Y_i = F\left(z_i K, A_i u_i L\right)$, and they do not exhibit capital-augmenting technological progress. Consider also that there is free mobility of capital and labor across sectors, so that rental rates are the same in all sectors, i.e., $r_i = r$, $w_i = w$ and, thus, $\omega_i = \omega$. We also assume unbiased technological change, so that $\gamma_i = \gamma$ for all sector i. Since $r_i = r$ for all i, we can derive from (2.3) that the relative prices are $p_i/p_m = A_m/A_i$. Hence, the relative prices are time invariant under these technologies, so that $\dot{p}_i/p_i - \dot{p}_m/p_m = 0$ for all i. All of these supply-side properties imply that the following partial mechanisms in (3.6) are not operative in this model: (a) the demand substitution mechanism, because the relative prices p_i/p_m are constant and the Homogeneity Condition (A.5) implies that $\sum_{j=1}^{m} \sigma_{ij} x_j = 0$; (b) the technological substitution mechanism because $\omega_i = \omega$, $\alpha_i = \alpha$ and $\pi_i = \pi$ for all sector i in this case; and (c) the technological change mechanism because $\gamma_i = \gamma$, $\alpha_i = \alpha$ and $\pi_i = \pi$ for all sector i. The dynamics of the sectoral employment shares are then only driven by the income mechanism.

Consider the following Stone-Geary preferences given by (4.2), which are a particular form of non-homothetic preferences. To derive the consumption demands, we first maximize (4.2) subject to the constraint (2.9). From the first order condition of this problem, we obtain

$$\frac{\phi_i^{\frac{1}{\varepsilon}} \left(c_i - \overline{c}_i\right)^{\frac{\varepsilon}{\varepsilon-1}-1}}{p_i} = \frac{\phi_j^{\frac{1}{\varepsilon}} \left(c_j - \overline{c}_j\right)^{\frac{\varepsilon}{\varepsilon-1}-1}}{p_j},$$

for all i an j. Manipulating this expression, we obtain

$$p_j \left(c_j - \overline{c}_j\right) = \left(\frac{\phi_j}{\phi_i}\right) p_i^{\varepsilon} p_j^{1-\varepsilon} \left(c_i - \overline{c}_i\right). \tag{B.1}$$

We now manipulate constraint (2.9) to obtain

$$\sum_{i=a,m,s} p_i \left(c_i - \overline{c}_i\right) + \underbrace{\sum_{i=a,m,s} p_i \overline{c}_i}_{\overline{e}} = e.$$

[1] See, e.g., Matsuyama (1992), Echevarria (1997), Laitner (2000), Caselli and Coleman (2001), Kongsamut et al. (2001), and Gollin et al. (2002).

Finally, we substitute (B.1) in the previous equation to get the demand functions:

$$c_i = \bar{c}_i + \frac{\phi_i (e - \bar{e})}{p_i^{\varepsilon} P}, \tag{B.2}$$

where

$$P = \sum_{k=a,m,s} \phi_k p_k^{1-\varepsilon}.$$

We next characterize the properties of these consumption demands by deriving the income and the price elasticities. Firstly, we obtain

$$\frac{\partial c_i}{\partial e} = \frac{\phi_i}{p_i^{\varepsilon} P} = \frac{c_i - \bar{c}_i}{e - \bar{e}}.$$

Hence, the income elasticity is given by

$$\mu_i = \left(\frac{e}{e - \bar{e}} \right) \left(1 - \frac{\bar{c}_i}{c_i} \right), \tag{B.3}$$

for all i.

Secondly, from (B.2) we obtain

$$\frac{\partial c_i}{\partial p_i} = - \left[\frac{\phi_i (e - \bar{e})}{p_i^{2\varepsilon} P^2} \right] \left[\varepsilon p_i^{\varepsilon - 1} P + (1 - \varepsilon) \phi_i + p_i^{\varepsilon} P \frac{\bar{c}_i}{e - \bar{e}} \right].$$

Using (B.1), (B.2) and (B.3) we obtain

$$\frac{\partial c_i}{\partial p_i} = - \left[\frac{\mu_i c_i (e - \bar{e})}{e} \right] \left[\frac{\varepsilon}{p_i} + \frac{c_i}{e - \bar{e}} - \varepsilon \mu_i \frac{c_i}{e} \right].$$

Hence, the own price elasticity is given by

$$\eta_{ii} = -\mu_i \left[\varepsilon \left(\frac{e - \bar{e}}{e} \right) (1 - \mu_i x_i) + x_i \right]. \tag{B.4}$$

In the same way, from (B.2) we obtain

$$\frac{\partial c_i}{\partial p_j} = - \left[\frac{\phi_i (e - \bar{e})}{p_i^{\varepsilon} P^2} \right] (1 - \varepsilon) \phi_j p_j^{-\varepsilon} - \frac{\phi_i \bar{c}_j}{p_i^{\varepsilon} P}.$$

Using (B.1), (B.2) and (B.3), we get

$$\frac{\partial c_i}{\partial p_j} = - (1 - \varepsilon) (c_i - \bar{c}_i) \mu_j \left(\frac{c_j}{e} \right) - c_j \left(\frac{c_i - \bar{c}_i}{e - \bar{e}} \right).$$

Hence, we can compute the *cross price elasticity* as

$$\eta_{ij} = \mu_i x_j \left[\varepsilon \mu_j \left(1 - \frac{\bar{e}}{e} \right) - 1 \right]. \tag{B.5}$$

Finally, by using the Slustky Equation (A.6), we obtain respectively from (B.4) and (B.5)

$$\eta_{ii}^{*} = \varepsilon \mu_i \left(1 - \frac{\bar{e}}{e} \right) (\mu_i x_i - 1),$$

and

$$\eta_{ij}^{*} = \varepsilon x_j \mu_i \mu_j \left(1 - \frac{\overline{e}}{e}\right).$$

With this value and the property $\eta_{ij}^{*} = x_j \sigma_{ij}$, we derive the Allen-Uzawa elasticities that are:

$$\sigma_{ij} = \varepsilon \mu_i \mu_j \left(1 - \frac{\overline{e}}{e}\right),$$

for all $i \neq j$, and

$$\sigma_{ii} = \left(\frac{\varepsilon \mu_i}{x_i}\right)\left(1 - \frac{\overline{e}}{e}\right)(x_i \mu_i - 1),$$

for all i.

Therefore, given the assumptions on technologies, we conclude from (3.6) that the change in the sectoral composition between any sectors i and j is only driven in this case by the income effect defined in (3.7).[2] This follows from the fact that the technological change mechanism is the same across sectors under these assumptions. In historical data for developed countries, we observe a substantial shift of employment from agricultural to service sector. Hence, this demand-based mechanism, which reduces exclusively to the income mechanism requires that the income elasticity of demand for agricultural goods should be smaller than that for services to be able to replicate the observed structural change in those economies. In terms of the utility function (4.2), this requirement translates into the condition that the minimum requirement in consumption should be larger for the agricultural good than for services. Finally, we must remark that structural change crucially depends on the ratio $\overline{c}_i / c_i$, which measures the intensity of minimum consumption requirement on the good produced by each sector. As shown in Alonso-Carrera and Raurich (2015), this intensity determines the value of the income elasticity of the demand of these goods and, therefore, governs structural change.

B.2. Structural change based on sectoral-biased technological progress

Baumol (1967) asserted that differential productivity growth across sectors is the engine of structural change. Ngai and Pissarides (2007) illustrate the mechanics of this second thesis of structural change by introducing an exogenous and sectoral-biased process of technological progress in a multisector growth model. More precisely, they propose a growth model similar to the one considered in the previous subsection with two main differences. On the one hand, they consider that there are not minimum consumption requirements, i.e., $\overline{c}_i = 0$ for all i. Observe that the following properties hold with this assumption: $\mu_i = 1$, $\sigma_{ij} = \varepsilon$ for $i \neq j$ and $\sigma_{ii} = \varepsilon (x_i - 1)/x_i$. Therefore, as follows from (3.6), the income mechanism in this new framework does not explain the change in the sectoral composition of employment. In addition, the aforementioned authors also assume that production functions are Cobb-Douglas and identical in all sectors except for their rates of total factor productivity growth. More precisely, they consider that technological change is sectoral-biased (i.e., $\gamma_i \neq \gamma_j$) and Hicks-neutral (i.e., $\lambda_i = 0$).

[2] Observe that Kongsamunt et al. (2001) imposed $\overline{c} = 0$ to generate an equilibrium path that exhibits, after some periods, balanced growth of aggregate variables together with a substantial structural change at the sectoral level. However, this assumption is irrelevant for having structural change.

As in the model of the previous subsection, this firstly implies that the technological substitution effect mechanism in (3.6) is not operative because $\alpha_i = \alpha$, $\pi_i = 1$, $r_i = r$, $w_i = w$ and, thus, $\omega_i = \omega$. Furthermore, since $r_i = r$ for all i, we can derive from (2.3) and (2.4) that the relative prices are as before $p_i/p_m = A_m/A_i$. However, relative prices are now time varying with $\dot{p}_i/p_i - \dot{p}_m/p_m = (\gamma_m - \gamma_i)$ because of the sectoral-biased technological change.

Therefore, in the model proposed by Ngai and Pissarides (2007) the change in the sectoral composition between any sectors i and j is fully determined by the demand substitution mechanism and the technological change mechanism in (3.6). In particular, by using the value of the Allen-Uzawa elasticities and the growth rate of relative prices, we obtain from (3.6) that

$$\Delta_{ij} \equiv \frac{\dot{u}_i}{u_i} - \frac{\dot{u}_j}{u_j} = (\varepsilon - 1)\left(\gamma_i - \gamma_j\right).$$

This condition imposes a condition on the elasticity of substitution between goods ε, which determines the demand substitution mechanism. Provided that technological progress is sectoral-biased, structural change takes place if and only if $\varepsilon \neq 1$. Furthermore, observed data show that structural change in the developed economies consists of a shift of employment from agriculture to services, as well as a larger growth rate of TFP in the former sector than in the latter. Hence, we need to impose that $\varepsilon < 1$ (i.e., low substitutability between goods in preferences) to replicate this pattern of structural change with the model considered in this subsection.

B.3. Structural change based on capital deepening

Acemoglu and Guerrieri (2008) proposed an alternative way of incorporating the thesis proposed by Baumol (1967): structural change is a consequence of the combination of sectoral differences in capital output elasticities with capital deepening. In this case, the increase in the capital-labor ratio raises the productivity of the sector with greater capital intensity relative to the other sectors, which causes differential productivity growth across sectors. To illustrate this thesis, consider a model with homothetic preferences (i.e., $\mu_i = 1$ for all i), unbiased technological change (i.e., $\gamma_i = \gamma$ for all sector i), free mobility of capital and labor across sectors (i.e., $r_i = r$, $w_i = w$ and $\omega_i = \omega$), and sectoral technologies that exhibit different capital income shares. In particular, consider that the production functions are given by (2.1) with $\pi_i = 1$ and without capital-augmenting technological progress for all i, such that

$$Y_i = A_i u_i L \left(k_i\right)^{\varphi_i}. \tag{B.6}$$

In this case, since $\alpha_i = \varphi_i$ for all i, $\mu_i = 1$ for all i, $\sigma_{ij} = \varepsilon = 1/\left(1-\rho\right)$ for all $i \neq j$, $\sigma_{ii} = \varepsilon\left(x_i - 1\right)/x_i$ for all i, and $\lambda_i = 0$, we obtain from (3.6) that structural change is given by

$$\Delta_{ij} \equiv \frac{\dot{u}_i}{u_i} - \frac{\dot{u}_j}{u_j} = -\varepsilon\left(\frac{\dot{p}_i}{p_i} - \frac{\dot{p}_j}{p_j}\right) + \left(\varphi_j - \varphi_i\right)\left(\frac{\dot{\omega}}{\omega}\right), \tag{B.7}$$

i.e., only the demand substitution mechanism and the technological substitution mechanism are operative in this model economy. The dynamic adjustment of aggregate capital-labor ratio k alters the sectoral composition through two channels. Firstly, capital deepening implies that production increases more in the sector with a larger capital output elasticity. In addition, this first change in the sectoral composition of aggregate production alters the relative prices and, therefore, the sectoral composition of demand for consumption goods, which also changes the sectoral location of inputs.

Note that Conditions (2.3) and (2.4) imply under the technologies (B.6) that

$$k_i = \left(\frac{\varphi_i}{1 - \varphi_i} \right) \omega,$$

and

$$\frac{p_i}{p_j} = \left[\frac{\varphi_j^{\varphi_j} \left(1 - \varphi_j\right)^{\left(1 - \varphi_j\right)}}{\varphi_i^{\varphi_i} \left(1 - \varphi_i\right)^{\left(1 - \varphi_i\right)}} \right] \omega^{\varphi_j - \varphi_i},$$

so that

$$\frac{\dot{p}_i}{p_i} - \frac{\dot{p}_j}{p_j} = \left(\varphi_j - \varphi_i\right) \left(\frac{\dot{\omega}}{\omega} \right).$$

Hence, we obtain from (B.7) that

$$\Delta_{ij} = (1 - \varepsilon) \left(\varphi_j - \varphi_i\right) \left(\frac{\dot{\omega}}{\omega} \right).$$

Structural change requires in this case $\varepsilon \neq 1$ and $\varphi_j \neq \varphi_i$. Therefore, in this case, the relative capital shares across sectors (φ_i/φ_j) also determine the direction and intensity of structural change. In particular, we can directly derive the conditions to replicate $\Delta_{ij} < 0$ observed in the data (where i is agriculture and j services) when $\varphi_i/\varphi_j > 1$, as is suggested by Valentinyi and Herrendorf (2008). Capital deepening implies that $\dot{\omega} > 0$ and the relative price of agriculture decreases. Hence, structural change reallocates labor from agriculture to services ($\Delta_{ij} < 0$) if and only if the goods produced in these sectors are complements, i.e., $\varepsilon < 1$.

B.4. Sectoral differences in capital-labor substitution

Alvarez-Cuadrado et al. (2017) shows that differences in the degree of substitutability between capital and labor across sectors also determine the relative importance of the technological substitution effect of structural change. We observe this by noting that in this case $\pi_i \neq \pi_j$, which determines the value and the sign of technological substitution mechanism in (3.9). Furthermore, observe that $\pi_i \neq \pi_j$ also implies that capital income shares differ across sectors (i.e., $\alpha_i \neq \alpha_j$). In this case, as capital accumulates, $\dot{\omega} \neq 0$ and $\dot{p}_l \neq 0$ for $l = i, j$, and if we assume homothetic preferences and non-biased, Hicks-neutral technological change, we obtain that structural change is driven by the demand and technological substitution mechanisms.

B.5. Long-run income and prices effects of structural change

As was pointed out before, some authors like, for instance, Buera and Kabosky (2009), argue that one should combine income and price effects to replicate satisfactorily the observed patterns of structural change. However, this interaction may exhibit some methodological inconveniences. To be more precise, consider a model that combines the non-homothetic preferences (4.2) with sectoral production functions that only differ in the rates of technological change (in particular, let us consider again a Hick-neutral technological progress). In this case, we observe that:

1. The income effects driving structural change vanish in the long-run as the economy grows because $\bar{c}_i / c_i$ tends to cero for all i. Therefore, structural change is only generated by price effects in the long run.

2. Some parameters simultaneously determine both income and price effects. In particular, the Allen-Uzawa elasticities σ_{ij} are functions of income elasticities μ^i and μ^j for these preferences. Therefore, the income and price effects in (3.6) depend on the same fundamentals, which may complicate the empirical identification of these mechanisms.

Comin et al. (2021) solve these two drawbacks of the models of structural change by considering a constant relative elasticities of income and substitution (CREIS) preferences. In particular, they consider that the instantaneous utility function $v(c_a, c_m, c_s)$ is implicitly defined given by

$$\sum_{i=a,m,s} \theta_i v^{\frac{\varepsilon_i - \eta}{\eta}} c_i^{\frac{\eta-1}{\eta}} = 1. \tag{B.8}$$

To derive the consumption demands, we first maximize $v(c_a, c_m, c_s)$ subject to (B.8) and the constraint (2.9). The first order condition with respect to c_i is given by

$$v^{-\sigma} \left(\frac{\partial v}{\partial c_i} \right) = \lambda p_i, \tag{B.9}$$

where λ is the Lagrange multiplier associated to (2.9), and where we obtain, by applying the implicit function theorem to (B.8), that

$$\frac{\partial v}{\partial c_i} = -\frac{(\eta - 1)\, \theta_i v^{\frac{\varepsilon_i - \eta}{\eta}} c_i^{-\frac{1}{\eta}}}{\sum_{i=a,m,s} (\varepsilon_i - \eta)\, \theta_i v^{\frac{\varepsilon_i - 2\eta}{\eta}} c_i^{\frac{\eta-1}{\eta}}}.$$

Aggregating (B.9) across sectors, and after some simple algebra, we obtain that the Marshallian demands are given by

$$c_i = \theta_i^{\eta} \left(\frac{p_i}{Q} \right)^{-\eta} v^{\varepsilon_i}, \tag{B.10}$$

with

$$Q \equiv \frac{e}{v} = \left(\frac{1}{v} \right) \left[\sum_{i=a,m,s} \theta_i^{\eta} v^{\varepsilon_i - \eta} p_i^{1-\eta} \right]^{\frac{1}{1-\eta}}. \tag{B.11}$$

By inserting (B.11) in (B.10), we obtain the consumption demand as

$$c_i = \theta_i^{\eta} p_i^{-\eta} e^{\eta} v^{\varepsilon_i - \eta}, \tag{B.12}$$

and the sectoral expenditure share as

$$x_i = \frac{\theta_i^\eta v^{\varepsilon_i - \eta} p_i^{1-\eta}}{\sum\limits_{i=a,m,s} \theta_i^\eta v^{\varepsilon_i - \eta} p_i^{1-\eta}}. \tag{B.13}$$

Log-differentiating the previous expression of c_i with respect to e, we obtain

$$\left(\frac{\partial c_i}{\partial e}\right)\left(\frac{1}{c_i}\right) = \frac{\eta}{e} + \left(\frac{\varepsilon_i - \eta}{v}\right)\left(\frac{\partial v}{\partial e}\right). \tag{B.14}$$

By applying the implicit function theorem to (B.11) we obtain after some simple algebra:

$$\frac{\partial v}{\partial e} = \frac{(1-\eta)\, v}{e\,(\bar{\varepsilon} - \eta)}.$$

Plugging this derivative in (B.14), we obtain the income elasticity as

$$\mu_i = \eta + (1-\eta)\left(\frac{\varepsilon_i - \eta}{\bar{\varepsilon} - \eta}\right), \tag{B.15}$$

where $\bar{\varepsilon} = \sum_{i=1}^m \varepsilon_i x_i$. Finally, by differentiating (B.12) we also obtain the price elasticities as

$$\eta_{ii} = -\eta + (\varepsilon_i - \eta)\left(\frac{p_i}{v}\right)\left(\frac{\partial v}{\partial p_i}\right),$$

and

$$\eta_{ik} = (\varepsilon_i - \eta)\left(\frac{p_k}{v}\right)\left(\frac{\partial v}{\partial p_k}\right).$$

By applying the implicit function theorem to (B.11), we obtain after some simple algebra:

$$\frac{\partial v}{\partial p_i} = -\frac{(1-\eta)\, x_i v}{(\bar{\varepsilon} - \eta)\, p_i}.$$

Hence, we can rewrite the price elasticities as

$$\eta_{ii} = \eta(x_i - 1) - x_i \mu_i,$$

and

$$\eta_{ik} = \eta x_k - x_k \mu_i.$$

Using (A.6) and the property $\eta_{ij}^* = x_j \sigma_{ij}$, we directly derive the Allen-Uzawa elasticities of substitution: $\sigma_{ik} = \eta$ and

$$\sigma_{ii} = \frac{\eta(x_i - 1)}{x_i}.$$

As in Subsection B.2, we also consider that the production functions are Cobb-Douglas and identical in all sectors except for their rates of total factor productivity growth, so that $\alpha_i = \alpha$, $\pi_i = 1$, $r_i = r$, $w_i = w$ and, thus, $\omega_i = \omega$. In this case, we obtain from (3.6) that

$$\Delta_{ij} = \left(\mu_i - \mu_j\right)\left\{\frac{\dot{e}}{e} - \sum_{k=1}^m \left[x_k\left(\frac{\dot{p}_k}{p_k}\right)\right]\right\} + \eta\left(\frac{\dot{p}_j}{p_j} - \frac{\dot{p}_i}{p_i}\right) + \left(\gamma_j - \gamma_i\right). \tag{B.16}$$

Comin et al. (2021) do not express structural change as a function of the growth rate of consumption expenditure e, but as a function of the growth rate of composite good v. However, we can prove their structural change condition is equivalent to (B.16). By log differentiating (B.11) with respect to time, we obtain

$$\frac{\dot{e}}{e} = \frac{\left(\frac{\dot{v}}{v}\right) \sum_{i=1}^{m} (\varepsilon_i - \eta)\, \theta_i^{\eta} v^{\varepsilon_i - \eta} p_i^{1-\eta} + \sum_{i=1}^{m} (1-\eta)\, \theta_i^{\eta} v^{\varepsilon_i - \eta} p_i^{1-\eta} \left(\frac{\dot{p}_i}{p_i}\right)}{(1-\eta) \sum_{i=1}^{m} \theta_i^{\eta} v^{\varepsilon_i - \eta} p_i^{1-\eta}}.$$

By using (B.13), we directly obtain

$$\frac{\dot{e}}{e} = \left(\frac{\overline{\varepsilon} - \eta}{1-\eta}\right) \left(\frac{\dot{v}}{v}\right) + \sum_{k=1}^{m} x_k \left(\frac{\dot{p}_k}{p_k}\right). \tag{B.17}$$

Finally, inserting (B.17) in (B.16), and using (B.15) and the fact that $\frac{\dot{p}_k}{p_k} = (\gamma_m - \gamma_k)$ as was shown in the previous section, we obtain

$$\Delta_{ij} = (\varepsilon_i - \varepsilon_j) \left(\frac{\dot{v}}{v}\right) + (1-\eta)\left(\gamma_j - \gamma_i\right),$$

which is exactly the expression of structural change provided by Comin et al. (2021).

C. Results from the sensitivity analysis

In this subsection, we carry out some robustness exercises to determine how the accounting results in the main text depend on some controversial assumptions of the parameterization used in this analysis. We obtain that the goodness of fit of our simulations can be improved with some small refinements of the parameterization of preferences and technologies.

C.1. The elasticity of substitution between consumption goods

We have shown that the demand substitution mechanism is very small because the point estimation of the elasticity of substitution ε is very close to zero, so that the Allen-Uzawa elasticity are also almost zero (see Figure 3). Herrendorf et al. (2013) test that the parameterization $\varepsilon = 0$ is lightly statistically preferable to the point estimation $\varepsilon = 0.002$ to fit the expenditure share data. We have shown that the $RMSE$ experiments an almost negligible increase when we use $\varepsilon = 0$ in our simulations of the employment shares. Therefore, small variations on the value of ε used in the simulations have a negligible impact on the goodness of fit and on the relative contribution of the demand substitution mechanism .

C.2. Goodness of fit with sectoral Cobb-Douglas technologies.

We check here how the employment shares simulated by considering Cobb-Douglas sectoral production functions fit the observed data. To this end, we consider a Cobb-Douglas specification for the sectoral production functions, where the capital income shares are given by the across-time arithmetic average of the observed sectoral capital shares, i.e., $\alpha_a = 0.61$, $\alpha_m = 0.29$ and $\alpha_s = 0.34$. This specifications differs with the CES specification both in the elasticities of substitution between capital and labor and in the factor-bias of the technological progress. The Cobb-Douglas specification of the sectoral production functions does not allow for identifying γ_i^a and γ_i^b separately, so that one can only estimate the growth rate of TFP that we denoted by γ_i. For this reason, we fix γ_i^a equal to the values of γ_i estimated by the aforementioned authors, i.e., $\gamma_a^a = 0.033$, $\gamma_m^a = 0.015$ and $\gamma_s^a = 0.01$, and we also set $\gamma_i^b = 0$ for $i = a, s, m$.

We simulate the path of the sectoral employment shares by considering the technological elasticities and the estimated growth rate of technological progress derived from the Cobb-Douglas production functions. We obtain that the fit of the simulated shares to the data in this case is significantly worse than in the simulations with the estimated CES production functions. Figure A.1 compares the time path of the employment shares simulated with the Cobb-Douglas specification with the shares simulated with the CES production functions and with the shares observed in the data. The Cobb-Douglas specifications capture reasonably well the overall change of the sectoral employment shares in the considered period. However, these alternative simulations performs a clearly much larger change in manufacturing and services than the observed change, especially in the second part of the period. As a consequence, the fit of the employment shares to the data in this case is significantly worse than in the simulations with the estimated CES production functions. The values of $RSME$ largely increase to 0.0598 and 0.0541 in manufacturing and services, respectively, when we use the Cobb-Douglas production functions, which represents an increase larger than 50%.

[Insert Figure A.1]

By considering Cobb-Douglas production functions, we are altering the technological substitution mechanism by changing the elasticities of substitution π_i, as well as the technological change mechanism by shutting down the factor-bias of the technical progress. As was pointed before, we cannot decompose both mechanisms.

C.3. The factor-bias of the sectoral technological progresses

The literature finds very controversial the values of capital-deepening technical progress from CES production functions (see, e.g., Antras, 2004; or Herrendorf et al., 2015). We deal with this problem by following an alternative way of estimating these values. We compute the rate of the net capital-deepening technical progress B_i as a residual of our structural change equation (3.5) when we take the observed growth rate of the employment share as the left-hand side of this equation.[3] In particular, we compute $\widehat{\gamma}_i^b$ as the cross-time average of

$$\frac{\frac{\dot{u}_i}{u_i} - \left(\widehat{G}_{it}^{RI} - \widehat{G}_{it}^{DS} - \widehat{G}_{it}^{TS} + \widehat{\gamma}_i^a - \frac{\dot{l}}{l}\right)}{\alpha_i \widehat{\pi}_i},$$

[3]We extremely acknowledge to a referee for suggesting this procedure.

where $\widehat{G}_{it}^{RI}$, $\widehat{G}_{it}^{DS}$, $\widehat{G}_{it}^{TS}$, $\widehat{\gamma}_i^a$ and $\widehat{\pi}_i$ were computed with the parameters estimated by Herrendorf et al. (2015). By following this procedure, we obtain that $\widehat{\gamma}_a^b = -0.033$, $\widehat{\gamma}_m^b = 0.041$ and $\widehat{\gamma}_s^b = -0.014$.

We simulate the sectoral employment shares by using these new estimations of $\widehat{\gamma}_i^b$. Figure A.2 and Table A.1 illustrates that the fit of these new simulation to the data on employment shares is slightly worse than the one in the benchmark simulations given in the main text. The value of the $RMSE$ increases a little bit in agriculture and manufacturing, whereas this value lightly decreases in services because the new simulation predicts better the total change in the employment share of this sector. In addition, Figure A.3 and Table A.2 shows that the new simulation implies remarkable changes in the relative contribution of the mechanisms of the structural change. The technological change mechanism maintains the direction of its force but reduces its relative importance in the three sectors. The lower contribution of the latter mechanism is compensated by the increase in the relative importance of the income mechanism and the technological substitution mechanism . Furthermore, the decomposition of the technological change mechanism shows that the capital-deepening technical change has now more weight in agriculture and less in services and, mainly, in manufacturing.

[Insert Figures A.2 and A.3 and Tables A.1 and A.2]

C.4. Goodness of fit with CREIS preferences

Finally, we develop the proposed accounting exercise by considering the CREIS preferences, which are implicitly defined through the constraint (B.8). By using cross-country data for the OECD countries, Comin et al. (2021) estimates the parameters of the utility function (B.8) by normalizing the income elasticity parameter in manufacturing to one, i.e., $\varepsilon_m = 1$. The results of this restricted estimation are $\eta = 0.35$, $\varepsilon_a = 0.01$, $\varepsilon_m = 1$ and $\varepsilon_s = 1.25$. With these parametrization, and by using the computations in Sub-section B.5, we obtain from the elasticities of consumption demands, which are still time-variant because they depend on consumption expenditures x_i. However, their variability is quite small and, more important, the income elasticities do not converge to one. In particular, the income elasticity of agriculture remains very small along the entire period, so that its cross-time average value is in this case much smaller than in the case with Stone-Geary preferences. Figure A.4 shows the time-path of the income elasticities of consumption demand under CREIS preferences, and Table A.3 reports their cross-time average.

[Insert Figure A.4 and Table A.3]

We simulate the sectoral employment shares by using the estimated elasticities of the consumption demand based on CREIS preferences. Figure A.5 and Table A.4 show that the fit of these new simulations to the data on employment shares is also very good. In fact, the fit with the CREIS preferences is in overall similar to the one with the Stone-Geary preferences. However, these two specifications of preferences work slightly different in each of the three sectors. In particular, the $RMSE$ is lightly smaller in services when we consider CREIS preferences, whereas the value of the $RMSE$ increases in agriculture and manufacturing. Finally, regarding the decomposition of the mechanisms of structural change, we show in Figure A.6 and Table A.5 that the relative importance of each of the mechanisms significatively changes with this alternative specification of preferences. The contribution of the demand substitution mechanism in the three sectors is now sizable, as consequence of the fact that the Allen-Uzawa elasticities differs now significantly from zero. In particular, this effect slows down the reallocation of employment across sectors. Furthermore, the increase in relative importance of this mechanism is mainly balanced with a reduction in the contribution of the Income mechanism.

[Insert Figures A.5 and A.6 and Tables A.4 and A.5]

We also show that this slightly better fit of the simulation based on CREIS preferences to employment share data is at the cost of a worse fit of the simulation to the expenditure share. Figure A.7 compares the simulations of consumption expenditure shares based on the two specifications of preferences with the observed data. While the fit of the simulation of the expenditure share in agriculture under both specifications is quite similar, the fit of the simulation of the expenditure shares in services and manufacturing with the Stone-Geary preferences is much better than with the CREIS preferences.

[Insert Figure A.7]

D. Competitive equilibrium

We now obtain the equilibrium path of the benchmark economy characterized by the sectoral production functions (4.1), the preferences (4.2) and the assumptions stated in Section 5 of the main text. To this end, we present and solve the optimization problems faced by consumers and firms. Firms operate under perfect competition, so that they decide how much capital and labor to rent in order to maximize their profits. By using conditions (2.3) and (2.4) with the production function (4.1), we obtain that the rental rates of capital and labor in sector i are given by

$$r_i = p_i \varphi_i Z_i A_i B_i^{\frac{\pi_i - 1}{\pi_i}} k_i^{\frac{-1}{\pi_i}} \left[\varphi_i \left(B_i k_i \right)^{\frac{\pi_i - 1}{\pi_i}} + \left(1 - \varphi_i \right) \right]^{\frac{1}{\pi_i - 1}}, \tag{D.1}$$

and

$$w_i = p_i \left(1 - \varphi_i \right) Z_i A_i \left[\varphi_i \left(B_i k_i \right)^{\frac{\pi_i - 1}{\pi_i}} + \left(1 - \varphi_i \right) \right]^{\frac{1}{\pi_i - 1}}, \tag{D.2}$$

respectively, and where we set $p_m = 1$ by considering the manufacturing good as a numeraire. We know that $w_i = w$ and $r_i = r$, for $i = \{a, m, s\}$. By manipulating these conditions from profit maximization, we obtain that the capital intensity in sector i is given by

$$k_i = \left[\frac{\varphi_i}{\left(1 - \varphi_i \right) \kappa_i} \right]^{\pi_i} B_i^{\pi_i - 1} \omega^{\pi_i}, \tag{D.3}$$

where ω is the rental rate ratio, i.e., $\omega = w/r$.

In each period, consumers are endowed with L units of time and K units of capital that inelastically supply to firms, for which they obtain an income per capita equal to

q. Consumers reallocate an exogenous fraction s of this income to accumulate capital, so that the capital stock in units of labor evolves as

$$k_{t+1} = \left(\frac{l_t}{l_{t+1}}\right)\left[\frac{sq_t/l_t + (1-\delta)\,k_t}{1+n}\right], \tag{D.4}$$

where δ is the depreciation rate. Hence, the consumption expenditure per capita is given by $e = (1-s)\,q$. A representative consumer faces the intratemporal problem of allocating consumption expenditure across sectors by maximizing the utility function (4.2) subject to the intratemporal budget constraint

$$e = \sum_{i=\{a,m,s\}} p_i c_i. \tag{D.5}$$

By manipulating the first order conditions of this problem, we obtain the following demand system:

$$c_i = \bar{c}_i + \phi_i \left[\frac{e-\bar{e}}{p_i^{\varepsilon} P}\right], \tag{D.6}$$

for $i = \{a, m, s\}$, and where

$$\bar{e} = \sum_{i=\{a,m,s\}} p_i \bar{c}_i,$$

and

$$P = \sum_{i=\{a,m,s\}} \phi_i p_i^{1-\varepsilon}.$$

Given a initial value of aggregate capital intensity k_0, a *competitive equilibrium* of this economy is path of prices $\{p_a, p_s\}$, of rental rates $\{w, r\}$, of sectoral capital intensities $\{k_a, k_m, k_s\}$, of sectoral employment shares $\{u_a, u_m, u_s\}$, of sectoral consumption per capita $\{c_a, c_m, c_s\}$, of sectoral value added in units of labor $\{y_a, y_m, y_s\}$ and of aggregate variables $\{q, e, k\}$, that satisfy: (a) the profit maximization conditions (D.1), (D.2) and (D.3); (b) the consumption demand system given by (D.5) and (D.6); (c) the law of motion of capital stock in units of labor (D.4); and, (d) the following market-clearing conditions:

$$c_i = u_i y_i l,$$

for $i = \{a, s\}$, and

$$u_m y_m l = c_m + sq,$$

$$u_a + u_m + u_s = 1,$$

$$k = \sum_{i=\{a,m,s\}} u_i k_i,$$

and

$$q = \sum_{i=\{a,m,s\}} p_i u_i l y_i.$$

E. Simulation of the competitive equilibrium

We now simulate the equilibrium path of the three economies considered in the main text: the benchmark economy and the counterfactual economies A and B. The three economies exhibit the same paths of the sectoral allocation of employment. In fact, the neutral component and the factor bias of the technical progress in the counterfactual economies are set so that they perfectly replicate the sectoral composition of employment obtained in the benchmark economy. More precisely, remember that the counterfactual economies are characterized by the following features of technical progress:

- *Economy A*: the capital-augmenting technical progress B_i remains constant at its initial value $B_i(0)$.
- *Economy B*: The neutral technical progress A_i grows at the constant rate, which is the same in the three sectors and equal to $\widehat{\gamma}_m^a$.

Obviously, since the three economies have different processes of technical progress, they also exhibit different equilibrium paths of GDP Q, consumption expenditure e, rental rates ratios ω_i, relative prices p_i and sectoral expenditure shares x_i. Figures A.8 to A.15 plots these cross-economies differences in the equilibrium paths of $\log Q$, $\log e$, $\log \omega_m$, p_a, p_s, x_a, x_m and x_s, respectively.[4]

[Insert Figures A.8 to A.15]

These differences in the equilibrium paths explain why the relative contribution of the mechanisms propagating the technical changes to the sectoral composition differs substantially across the four economies as is shown in the main text.

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Table A.1. Performance of the simulations under the alternatives values of γ_i^b

	Agriculture: u_a	*Services:* u_s	*Manufacturing:* u_m
Pearson's R	0.9815	0.9608	0.8222
RMSE	0.0182	0.0240	0.0462

Table A.2. Average growth rate of u_i under the alternatives values of γ_i^b

	Agriculture	*Services*	Manufacturing
Data: G_i	-0.0343	0.0068	-0.0100
Predicted: $\widehat{G}_i$	-0.0348	0.0070	-0.0132
Decomposition :			
(a) Income mechanism: $\widehat{G}_i^I$	0.0047 (-0.1337)	0.0210 (3.1648)	-0.0562 (4.2588)
(b) Demand subst. mechanism: $\widehat{G}_i^{DS}$	1.1×10^{-5} (-0.0003)	-5.4×10^{-6} (-0.0008)	1.4×10^{-5} (-0.0010)
(c) Tech. subst. mechanism: $\widehat{G}_i^{TS}$	-0.0220 (0.6325)	-0.0024 (-0.3771)	0.0094 (-0.7099)
(d) Tech. change mechanism: $\widehat{G}_i^{TC}$	-0.0182 (0.5070)	-0.0124 (-1.8033)	0.0386 (-3.1648)
- Neutral component	-0.0500 (1.4376)	-0.0157 (-2.2936)	0.0535 (-4.0590)
- Capital deepening component	0.0265 (-0.9306)	0.0042 (0.4903)	-0.0062 (0.8943)
(e) Hours worked effect: $\widehat{G}_i^{HW}$	0.0007 (-0.0205)	0.0007 (0.1024)	-0.0050 (0.3771)

Notes: The decomposition satisfies $\widehat{G}_i = \widehat{G}_i^I + \widehat{G}_i^{DS} + \widehat{G}_i^{TS} + \widehat{G}_i^{TC} + \widehat{G}_i^{HW}$.
The value in parenthesis is the relative contribution of each mechanism,: $\widehat{G}_i^j / \widehat{G}_i$.

Table A.3. Average values of demand elasticities under CREIS preferences

Sector	Income Elasticities (μ_i)	Allen-Uzawa Elasticities (σ_{ij})		
		Agriculture	Manufacturing	Services
Agriculture	0.06798	-12.8792	0.35	0.35
Manufactures	0.88915	0.35	-0.8965	0.35
Services	1.09652	0.35	0.35	-0.1641

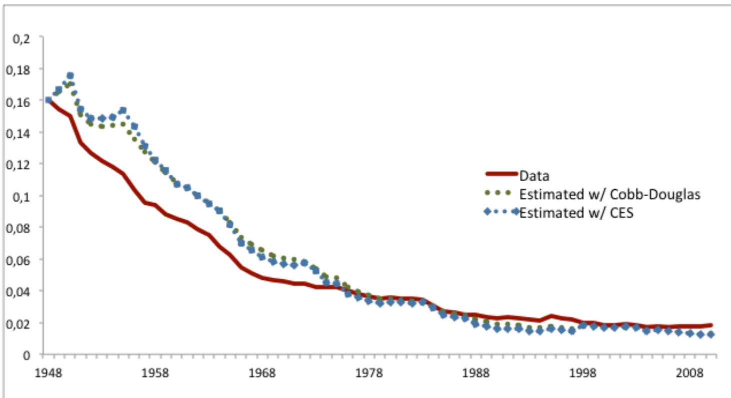
Table A.4. Performance of the simulations under CREIS preferences

	Agriculture: u_a	*Services:* u_s	*Manufacturing:* u_m
Pearson's R	0.9699	0.9675	0.8729
RMSE	0.0248	0.0202	0.0500

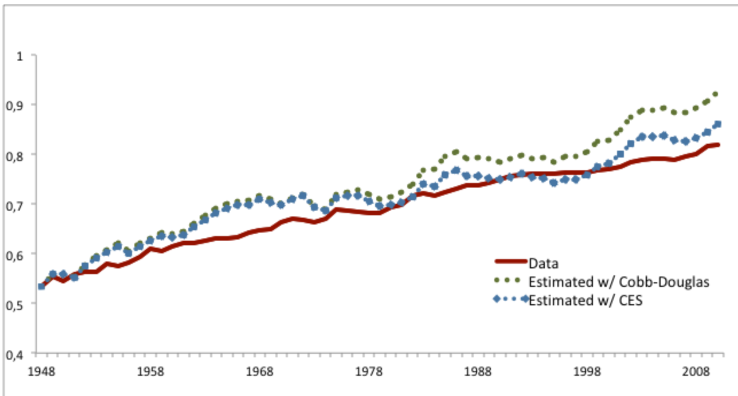
Table A.5. Average growth rate of u_i under CREIS preferences

	Agriculture	*Services*	Manufacturing
Data: G_i	-0.0343	0.0068	-0.0100
Predicted: $\widehat{G}_i$	-0.0342	0.0073	-0.0155
Decomposition :			
(a) Income mechanism: $\widehat{G}_i^I$	0.0014 (-0.0402)	0.0223 (3.0509)	-0.0601 (3.8875)
(b) Demand subst. mechanism: $\widehat{G}_i^{DS}$	0.0092 (-0.2697)	-0.0015 (-0.2106)	0.0024 (-0.1544)
(c) Tech. subst. mechanism: $\widehat{G}_i^{TS}$	-0.0220 (0.6427)	-0.0024 (-0.3227)	0.0094 (-0.6058)
(d) Tech. change mechanism: $\widehat{G}_i^{TC}$	-0.0236 (0.6881)	$-$ 0.0118 (-1.6154)	0.0379 (-2.4491)
- Neutral component	-0.0500 (1.4607)	-0.0160 (-2.1918)	0.0535 (-3.4639)
- Capital deepening component	0.0264 (-0.7726)	0.0042 (0.5764)	-0.0157 (1.1049)
(e) Hours worked effect: $\widehat{G}_i^{HW}$	0.0007 (-0.0209)	0.0007 (0.0979)	-0.0050 (0.3218)

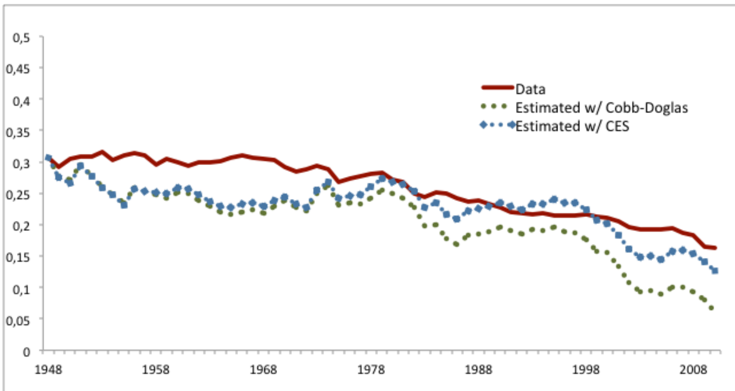
Notes: The decomposition satisfies $\widehat{G}_i = \widehat{G}_i^I + \widehat{G}_i^{DS} + \widehat{G}_i^{TS} + \widehat{G}_i^{TC} + \widehat{G}_i^{HW}$.
The value in parenthesis is the relative contribution of each mechanism: $\widehat{G}_i^j/\widehat{G}_i$.



Panel A. Agriculture



Panel B. Services



Panel C. Manufacturing

Figure A.1. Sectoral employment shares with Cobb-Douglas technologies

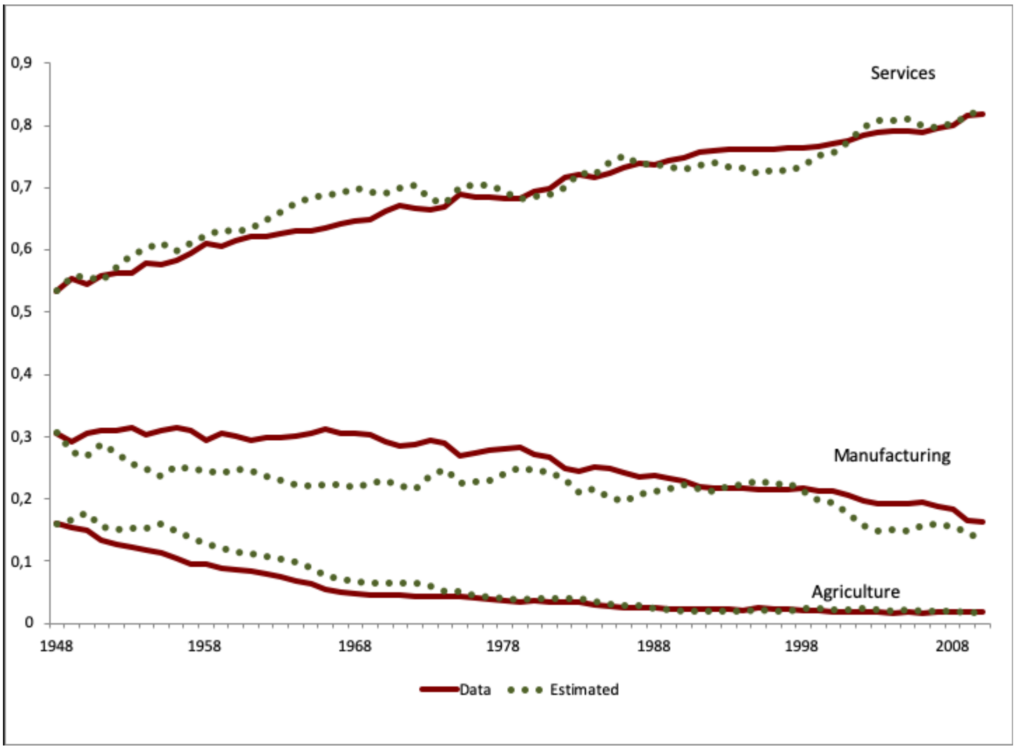


Figure A.2. Fit of the sectoral employment share under alternatives values of γ_i^b

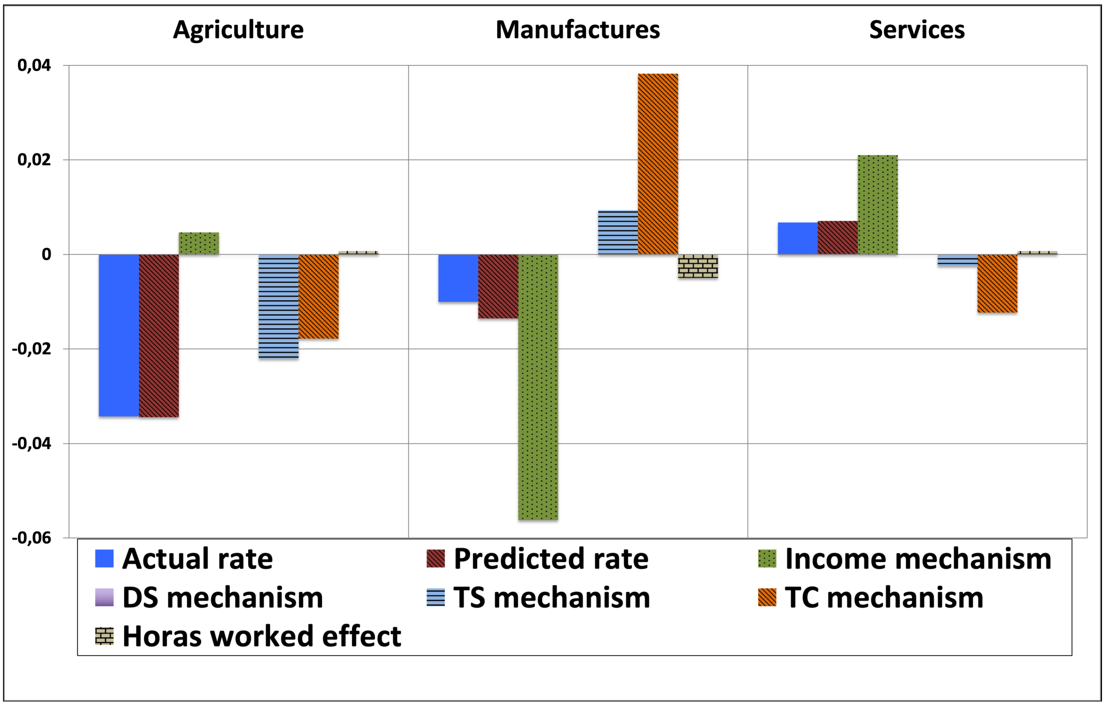


Figure A.3. **Decomposition of the average growth rate of the sectoral employment shares under alternatives values of** γ_i^b

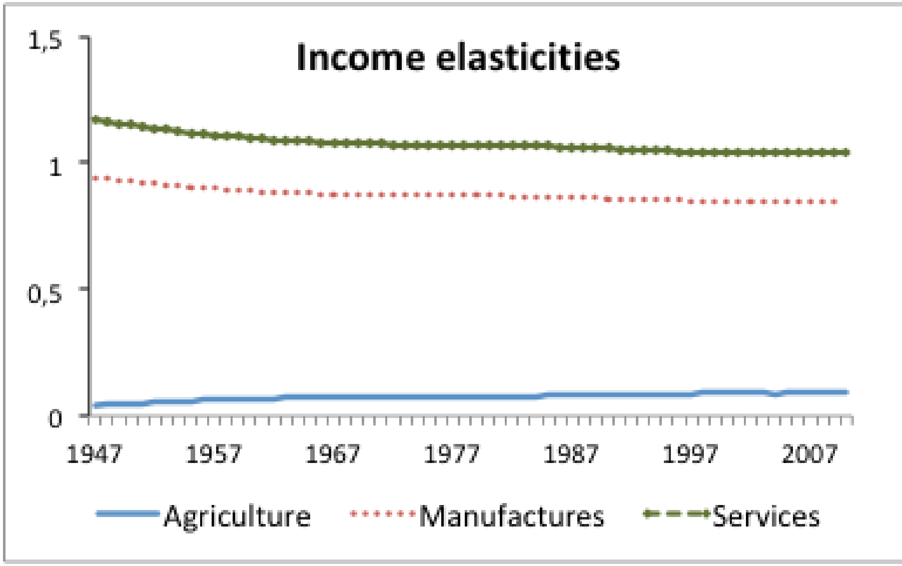


Figure A.4. Income elasticities of consumption demand under CREIS preferences

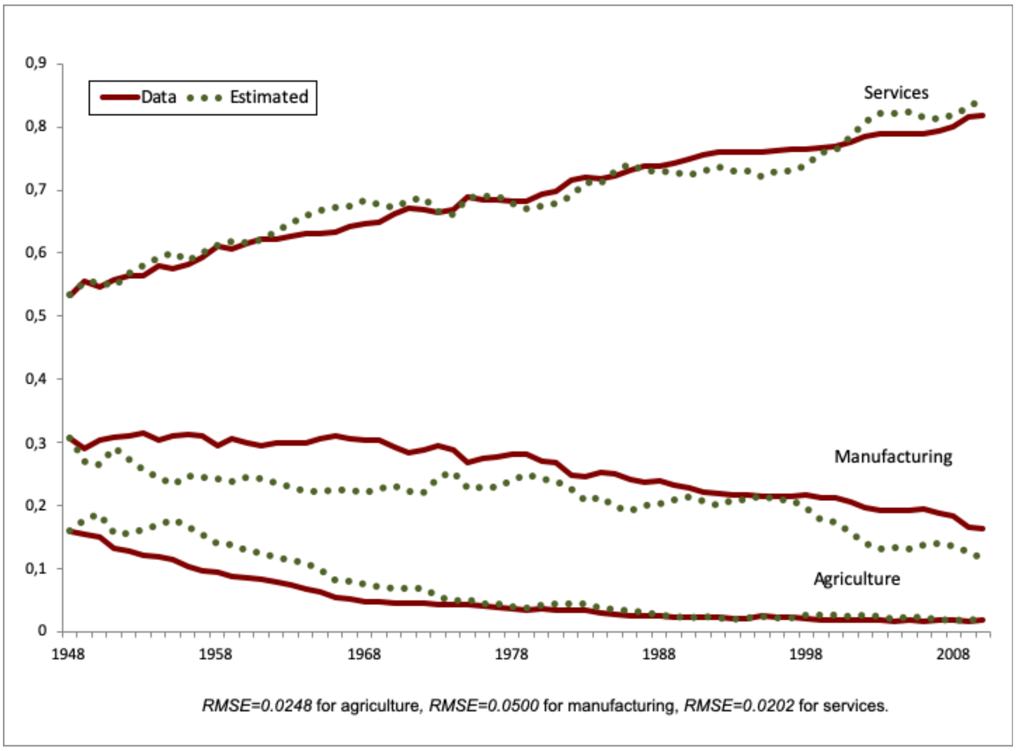


Figure A.5. Fit of the sectoral employment shares under CREIS preferences

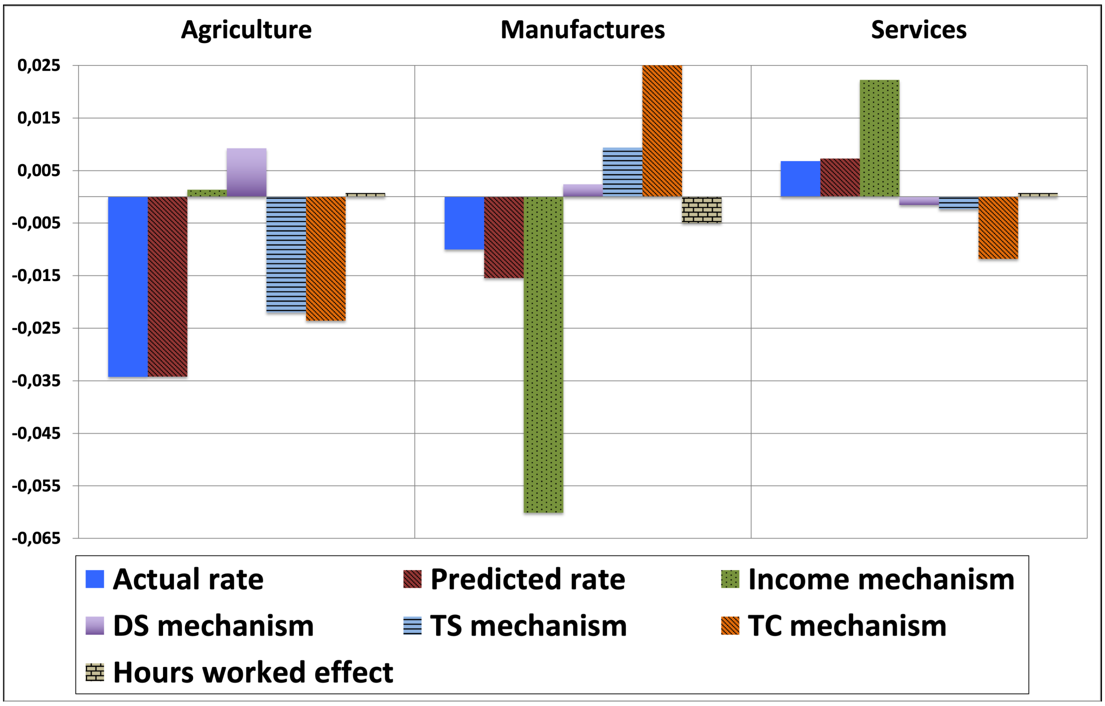
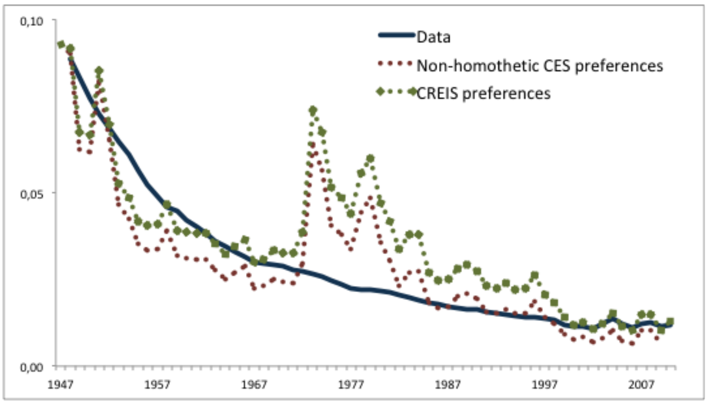
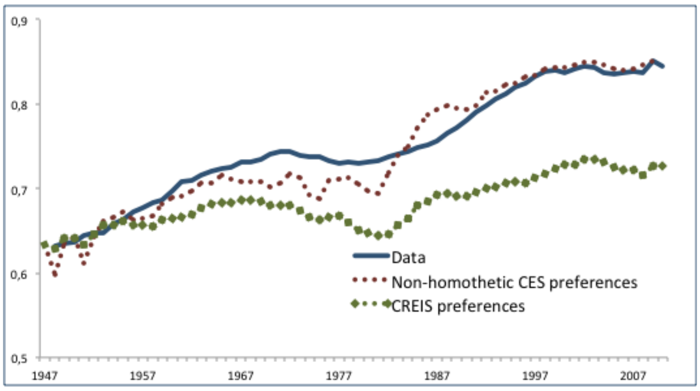


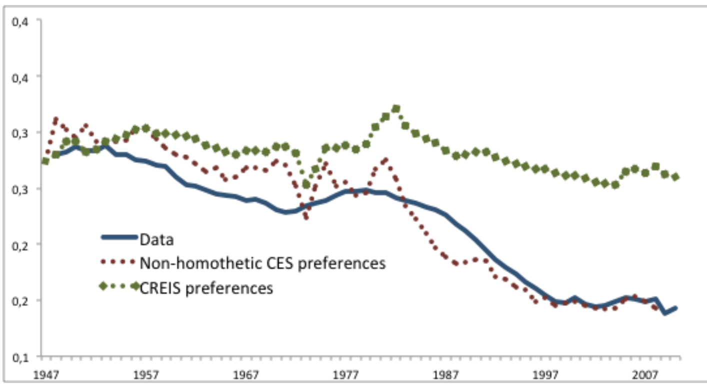
Figure A.6. Decomposition of the average growth rate of the sectoral employment shares with CREIS preferences



Panel A. Agriculture



Panel B. Services



Panel C. Manufacturing

Figure A.7. Fit of expenditure shares.

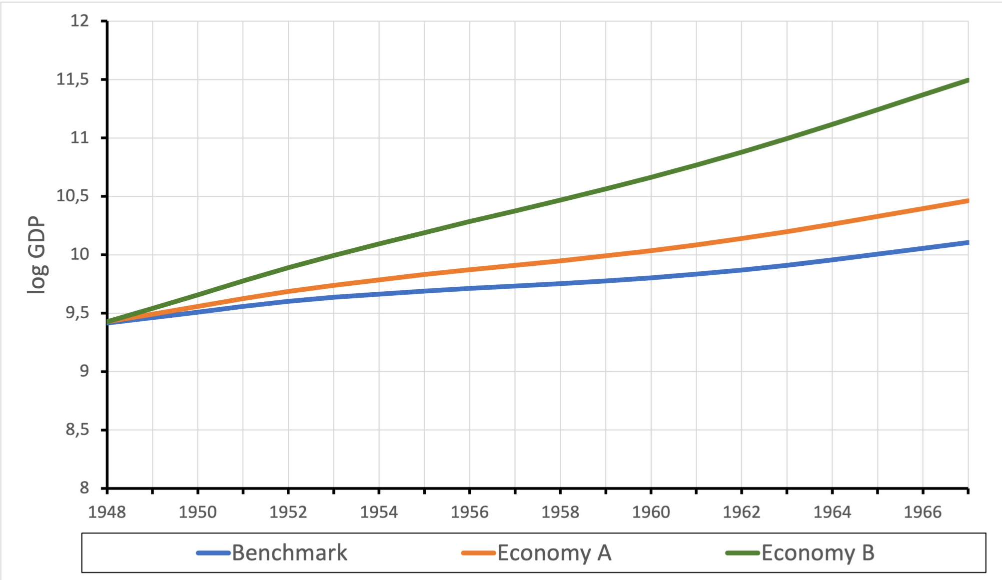


Figure A.8. Equilibrium paths of GDP Q

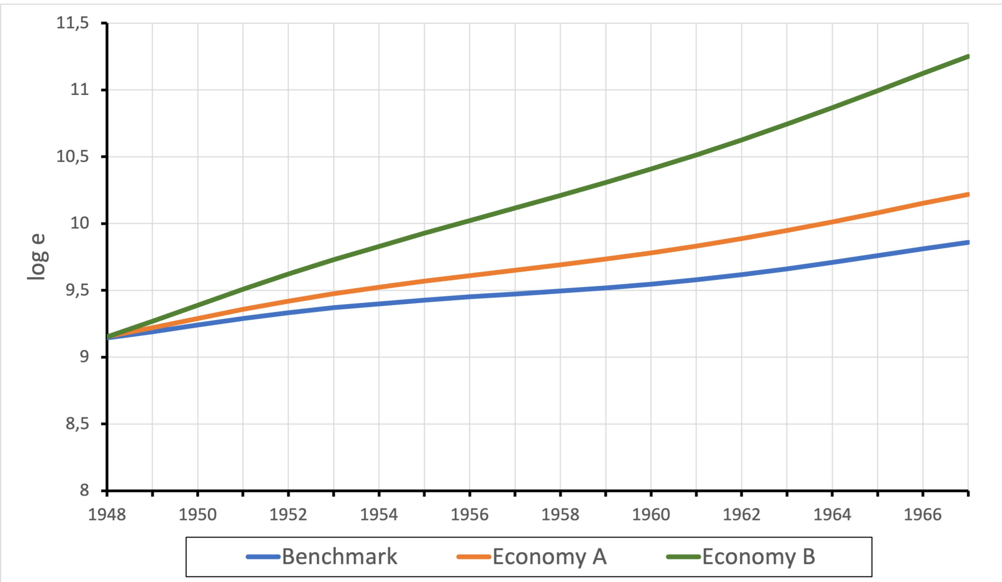


Figure A.9. Equilibrium paths of consumption expenditure e

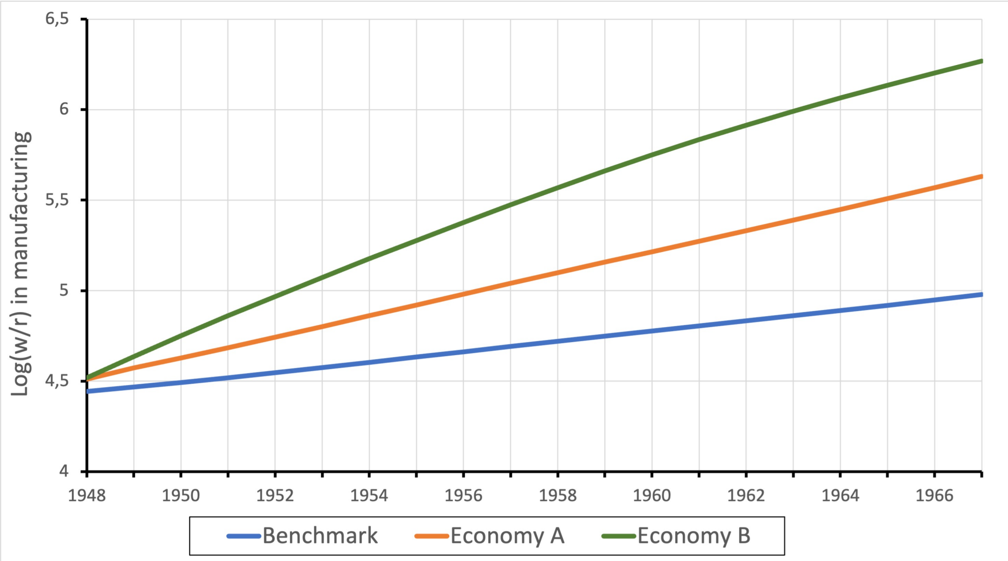


Figure A.10. Equilibrium paths of rental rate ratio in manufacturing

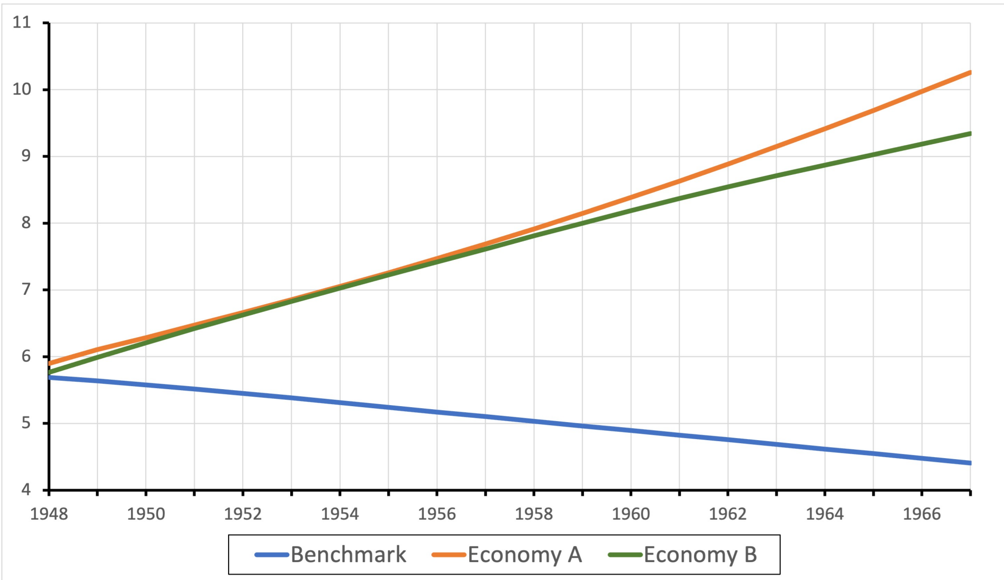


Figure A.11. Equilibrium paths of relative price in agriculture p_a

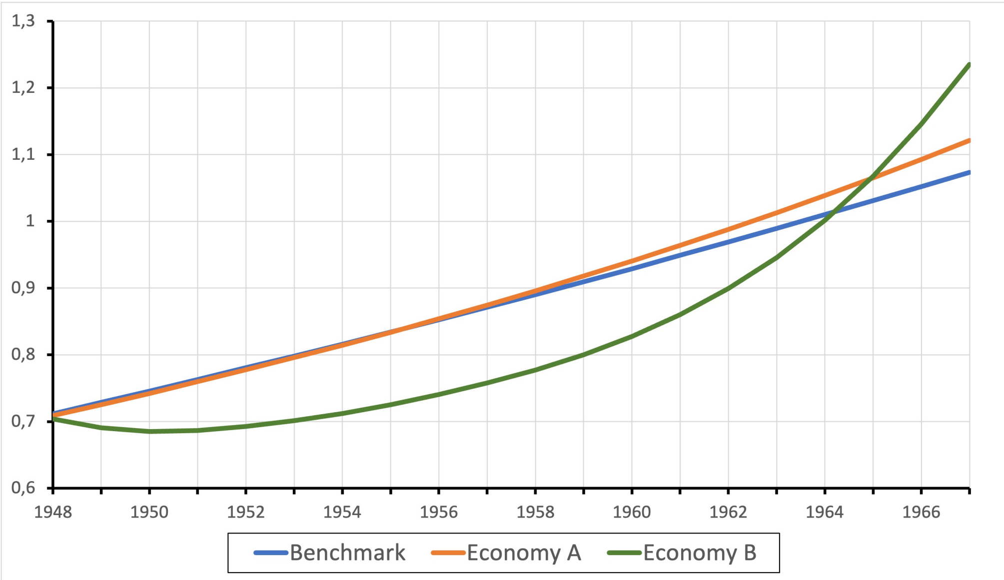


Figure A.12. Equilibrium paths of relative price in services p_s

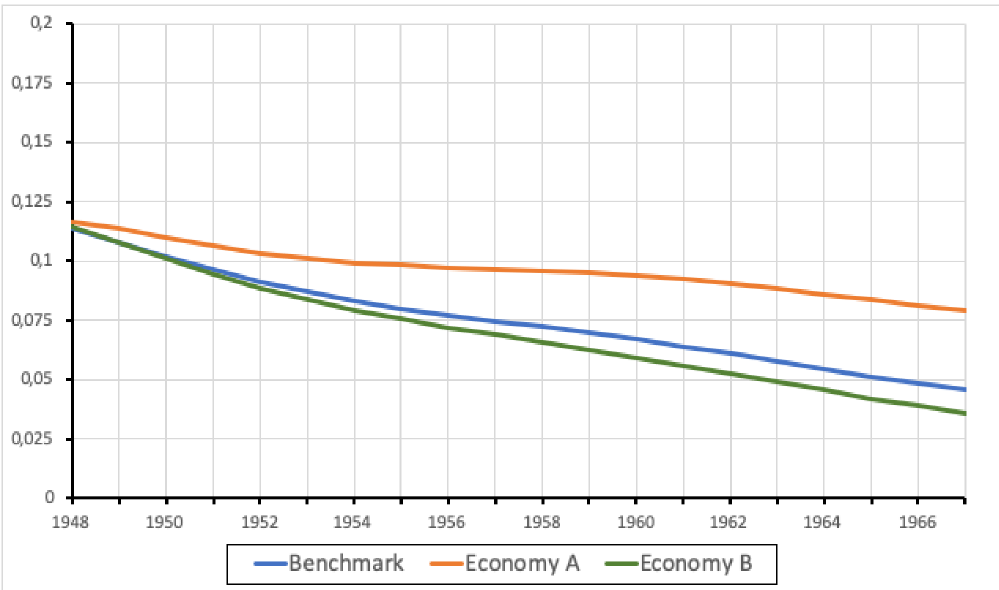


Figure A.13. Equilibrium paths of expenditure share in agriculture x_a

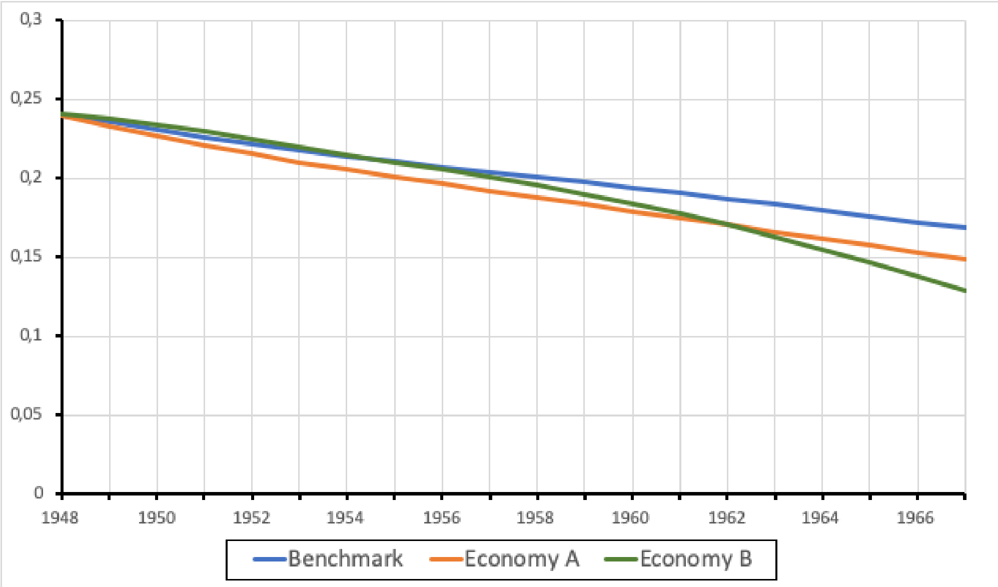


Figure A.14. Equilibrium paths of expenditure share in manufacturing x_m

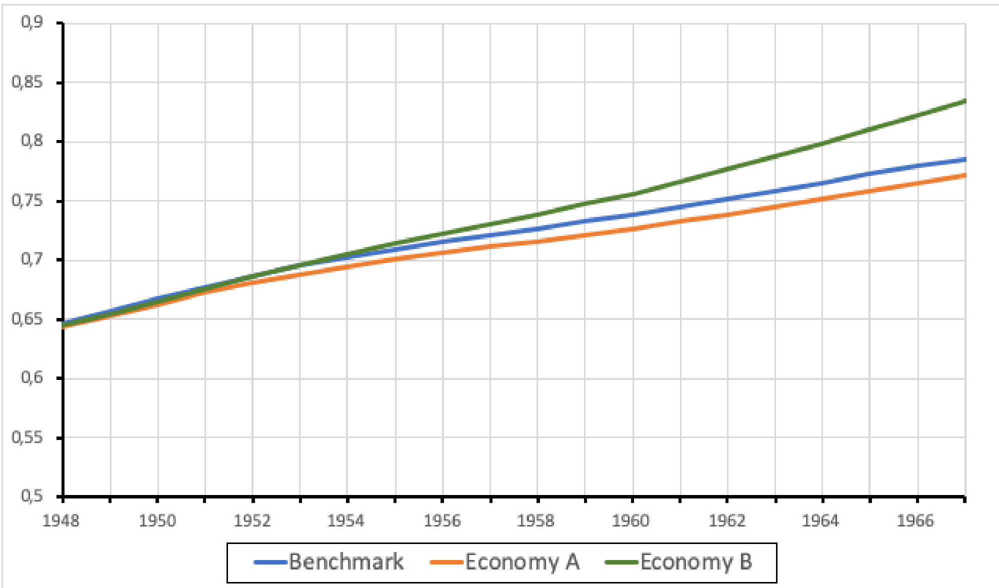


Figure A.15. Equilibrium paths of expenditure share in services x_s