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Revisiting the process of aggregate growth recovery after a capital destruction

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ABSTRACT

We study the implications of a growth model including social capital and habit formation concerning the recovery of economies that suffer from an exogenous destruction in their capital stock. Habits exhibit very low persistence and depend only on last period's consumption as suggested by empirical evidence. In addition to physical capital, agents invest in social capital which generates both market (production) and non-market (utility) returns. We study an infinite horizon model and compare its implications to a model with habit formation but without social capital. Our framework is more efficient in generating dynamic patterns that replicate the behavior of the main economic variables during the reconstruction period. High investment in social capital at the beginning of the transition is a key element of our results.

1. Introduction

This paper focuses on the dynamic transition of economies that experiment the consequences of a destruction in their capital stock. Empirical evidence based on post-war reconstruction highlights the non-monotonic adjustment path followed by these economies, which is in stark contrast with the monotonic process of development observed in economies that do not experience significant negative shocks in their capital stock. In particular, the post-war recovery seems to be characterized by the following three key stylized facts. First, growth rates are initially large and decrease slowly during the adjustment process. Comparing five European countries after World War II with a control group including the US, Canada and Australia, Alvarez-Cuadrado (2008) suggests that post-war growth rates in Europe were much larger and the convergence was significantly slower. Furthermore, this convergence does not need to be monotonic. In fact, in some economies the growth rate exhibits a hump-shape with the peak reached several years after the end of the conflict. Papageorgiou and Perez-Sebastian (2006) report a similar non-monotonic behavior for South Korea and Japan.

Second, the saving rate also follows a characteristic hump-shaped pattern. For European countries, Alvarez-Cuadrado (2008) shows that the saving rate increases monotonically during the first years of the transition before reaching its maximum after more than a decade and then slowly decreases. Maddison (1992) and Antras (2001) find similar evidence for a larger panel of countries while the case of Japan has been documented and discussed by Hayashi (1989) and Christiano (1989).

Finally, the physical capital–output ratio is slightly decreasing during the first years of the transition before increasing monotonically. Alvarez-Cuadrado (2008) documents that the increase seems to start around 1955 for European countries while Christiano (1989) identifies a similar behavior for Japan except that the increase seems to take place during the mid 1960's.

In order to generate the first two patterns, the literature usually relies on preferences exhibiting non homotheticity with the introduction of a consumption reference into the utility function. This reference can take the form of an exogenous consumption

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reference (Christiano, 1989; Antras, 2001), consumption externalities (Alvarez-Cuadrado et al., 2004; Alvarez-Cuadrado, 2008) or habit formation (Carroll et al., 2000; Alvarez-Cuadrado et al., 2004). One common feature to all these approaches is the fact that the reference stock is either constant or at least does not adjust immediately. In other words, the reference stock is not only determined by the previous period's consumption but exhibits some persistence. This time persistence in the consumption reference is a key element since it allows to moderate the growth rate of the reference stock which is necessary in order to replicate accurately the dynamics of the transition. Alvarez-Cuadrado et al. (2004) and Alvarez-Cuadrado (2008) follow the approach of Carroll et al. (1997, 2000) by using a reference stock which is a weighted average of past consumption levels. This generates a reference stock which adjusts slowly in time and combined with a neoclassical production function allows to generate non-monotonic transitional paths. One key element of this approach is the speed at which the reference stock adjusts which determines the relative importance of recent consumption levels.

The previous theory for explaining the observed dynamics of countries experiencing an exogenous destruction in their capital stock has two main drawbacks. On the one hand, the large persistence of the consumption reference required by the theory seems empirically implausible. Concerning specifically habit formation, while empirical evidence shows that individuals form habits and assess present satisfaction by comparison with standards of living enjoyed in the past (Fuhrer, 2000; Carrasco et al., 2005; Alvarez-Cuadrado et al., 2016), few studies have tried to estimate properly the speed of adjustment of the habit stock. A notable exception is the work of Fuhrer (2000) who finds that the speed of adjustment is very large implying that the reference stock is only determined by last period's consumption level. Moreover, a large speed of adjustment is also suggested by the equity premium literature (see, e.g., Constantinides, 1990; Boldrin et al., 2001). However, a model without a large habit persistence and a neoclassical production function seems unable to replicate properly the non-monotonic adjustment observed during the recovery. The model fails by generating growth rates with low persistence and a saving rate that reaches its maximum too early together with a hump that is too large.

On the other hand, with independence of the persistence degree of the consumption reference, the aforementioned theory is unable to replicate the initial decrease in the physical capital–output ratio and, therefore, its U-shaped dynamic path. The final increase in this ratio implies that a decreasing returns mechanism must be at work and, therefore, rules out the use of production functions without decreasing returns to capital at the private level.

One possible way to improve the model with habits that adjust immediately is to introduce an alternative mechanism that moderates the increase in the habit stock and/or the decrease in the marginal productivity of capital. We borrow the idea of productive consumption by introducing a second consumption good which increases aggregate productivity.[1] However, the intratemporal decision of the individual must have intertemporal consequences in order to affect savings and growth. To this end, we also propose the second consumption good to be durable, i.e., to take the form of a state variable. We have in mind some intangible goods that have the property of being productive durable consumption goods like, for instance, health or social capital. We choose to focus on social capital because this variable is largely associated to conflicts and aggregate productivity. In particular, empirical evidence suggests that social capital, in any of the definitions considered in the literature, is heavily affected by war and civil conflicts since trust, social cohesion and associational membership seem to decrease largely during these events (Becchetti et al., 2013; De Luca and Verpoorten, 2015). This literature also suggests that investment in social capital is large in the years following the conflict implying a fast recovery of the social capital stock. Our model is in line with this outcome concerning social capital.

Our objective is to show that a model where the stock of habits adjusts immediately combined with social capital accumulation is able to reproduce properly the observed features of the transition following an exogenous destruction of the capital shock. In order to do so, we introduce social capital as a second good into the utility function of the representative agent. We consider that agents accumulate social capital in addition to physical capital. Several definitions of social capital have been proposed in the literature (Putnam et al., 1994; Durlauf and Fafchamps, 2005) but some elements are common to all: the importance of networks, norms and values which characterize social organization and generate externalities at the community level. It is by now acknowledged that social capital shares common features with other types of capital (human and physical) such as its intertemporal dimension and its capacity to generate both benefits and externalities (Agénor and Dinh, 2015). It then seems natural to study the association between social capital and fundamental economic variables. Indeed, social capital seems to be positively correlated with economic growth (Knack and Keefer, 1997; Temple and Johnson, 1998) and can thus influence the behavior of growth and saving rates. Social capital might determine economic outcomes by altering the effective production technology (Fang, 2001), influencing cooperative behavior and facilitating trade (Routledge and Von Amsberg, 2003) or by fostering the accumulation of human capital (Chou, 2006; Bofota et al., 2016).

The presence of a durable good that simultaneously enters, in a non rival fashion, in the utility and production functions has large consequences on the dynamics of the economy. On one side, the intratemporal allocation between consumption and social capital modifies the intertemporal allocation of consumption. The incentive to accumulate social capital is enhanced by its stock nature and moderates the increase of the habit stock. On the other side, the rate of return on physical capital is positively affected by social capital which attenuates the neoclassical effect due to decreasing returns. Thus, the crucial point being that during a conflict not only physical capital is destroyed, but social capital also dramatically decreases, so that posterior investment in the latter can more than compensate in the short run the effect of physical capital accumulation on the rate of return. In sum, the combination of both mechanisms based on the presence of social capital substitutes the one related to the persistence of the habit stock.

[1] See Steger (2002) for a model where the unique consumption good enhances aggregate productivity.

We then simulate numerically the model in order to show that such a mechanism is able to reproduce accurately the transition of European countries during the post-war period. More specifically, our numerical results are consistent with empirical evidence concerning output growth rates, the hump-shaped pattern of the saving rate as well as the initial decrease in the physical capital–output ratio and its subsequent increase. By simulating also the versions of our benchmark model without social capital and with habit persistence, we clearly illustrate the relevance of the proposed mechanism in replicating the observed dynamics.

The paper is organized as follows. Section 2 presents the model and characterize the competitive equilibrium. Section 3 presents our numerical simulations and compares the results to a model without social capital. We also include in this section a sensitivity analysis concerning key parameters, habit persistence and foreign aid. Finally, Section 4 is devoted to the conclusion.

2. The model

We consider an economy populated by identical and infinitely lived individuals. Population is constant and, therefore, we normalize its size to one. This economy is composed of a unique sector, which produces an homogeneous good that individuals use for consumption or to accumulate physical and social capital. The representative agent supplies inelastically one unit of labor at each period and derives utility from consumption c_t as well as from his social development and integration, which is positively determined by the stock of social capital e_t. We consider that the representative individual forms aspirations in consumption and in social development. On the one hand, consumption is subject to habit formation, where the reference stock is only determined by last period's consumption c_{t-1}. On the other hand, preferences also exhibit a catching up with the Joneses feature with respect to social capital, i.e., individuals take the past average stock of social capital in the economy as a reference with respect they compare their own stock of social capital to.

We follow Glaeser et al. (2002) in considering that agents accumulate social capital and that the latter enters directly into the utility function thus generating non-market returns. We also suppose that investment in social capital requires units of the final good. As stated in Bofota et al. (2016), this assumption allows to capture the fact that maintaining social capital might be costly in terms of resources that could be allocated to consumption or physical capital.[2] In our setup, any private spending that has a social component can be interpreted as social capital investment. We denote by m_t the amount of final good devoted to accumulate social capital. The accumulation of social capital then proceeds as follows:

$$e_{t+1} = \phi m_t + (1-\eta)e_t, \tag{1}$$

where $\eta \in (0,1)$ is the depreciation rate of social capital and $\phi > 0$ is the scale factor of investing in the accumulation of social capital. Given its intangible characteristics, social capital depreciates quite naturally with time and requires continuous investment efforts. Moreover, social capital is partially community specific implying that when individuals leave their neighborhoods, a part of their accumulated social capital is lost in the process. For simplicity, we abstract from any spatial considerations, which is one of the reasons justifying the introduction of a depreciation term concerning social capital: this term is partially a reduced form of the effect of individuals' mobility on their stock of social capital.

In order to take into account the different elements exposed before, we propose the following utility function:

$$U = \sum_{t=0}^{\infty} \beta^t [\theta \ln(c_t - \rho_c c_{t-1}) + (1-\theta)\ln(e_t - \rho_e \bar{e}_{t-1})], \tag{2}$$

where $\theta \in (0,1)$ is the relative preference for individual consumption, $\rho_c \in (0,1)$ is the parameter governing the intensity of habits in consumption and $\rho_e \in (0,1)$ is the one governing the intensity of aspirations in social capital.

The representative consumer faces the following budget constraint:

$$k_{t+1} = w_t + (1+r_t)k_t - c_t - m_t, \tag{3}$$

where r_t is the rate of return on physical capital and w_t is the wage rate.

Production takes place through a representative firm which produces the homogeneous good y_t with a Cobb–Douglas production function. However, we assume that total factor productivity is an increasing function of the average stock of social capital. We suppose that an economy with more social development and with more networks and trust among its inhabitants also exhibits a larger aggregate productivity. The production function takes the following form:

$$f(k_t, \bar{e}_t) = A(\bar{e}_t)k_t^{\alpha}, \tag{4}$$

with $\alpha \in (0,1)$, and where $A(\bar{e}_t)$ is total factor productivity which is a function of average social capital. We suppose that $A(0) = 0$, $A'(\bar{e}_t) > 0$ and the elasticity of $A(.)$ defined as ϵ_A is a constant. We also assume perfect competition implying:

$$r_t = \alpha A(\bar{e}_t)k_t^{\alpha-1} - \delta, \tag{5}$$

[2] Investment in social capital might also require the use of time as assumed by Glaeser et al. (2002). However, if time is the unique input for producing new social capital, then there would be a large negative correlation between social capital investment and the wage level. This explains our reason for considering that the accumulation of social capital requires market goods. In fact, without loss of generality, we consider for simplification that time is not required to accumulate social capital.

and

$$w_t = (1-\alpha)A(\overline{e}_t)k_t^{\alpha}, \tag{6}$$

where $\delta \in (0,1)$ is the depreciation rate of physical capital.

The representative consumer faces the problem of choosing consumption c_t, investment in social capital m_t and investment in physical capital to maximize (2) subject to (1) and (3), by taking as given w_t, r_t, $\overline{e}_t$ for all t and the initial conditions k_0, e_0 and $c_{-1} > 0$. This is a standard dynamic optimization problem with control variables c_t and m_t and state variables k_t, e_t and c_{t-1}. By following the standard procedure, we find in Appendix A the first order conditions and rearrange the expressions to summarize the necessary conditions for optimality by the dynamic system composed of the difference equations (1), (3),

$$\frac{1}{c_t-\rho_c c_{t-1}} - \frac{\beta\rho_c}{c_{t+1}-\rho_c c_t} = \left(\frac{\beta}{c_{t+1}-\rho_c c_t} - \frac{\beta^2\rho_c}{c_{t+2}-\rho_c c_{t+1}}\right)\left(1+r_{t+1}\right), \tag{7}$$

and

$$\left(\frac{\theta}{1-\theta}\right)\left[\frac{1}{c_t-\rho_c c_{t-1}} - \frac{\beta(1-\eta+\rho_c)}{c_{t+1}-\rho_c c_t} + \frac{\beta^2\rho_c(1-\eta)}{c_{t+2}-\rho_c c_{t+1}}\right] = \frac{\beta\phi}{e_{t+1}-\rho_e e_t}. \tag{8}$$

Eq. (7) describes the intertemporal allocation of consumption and takes into account habit formation. This intertemporal condition is standard except for the presence of average social capital as a determinant of total factor productivity. The accumulation of social capital will increase the rate of return and moderate the decrease due to physical capital accumulation. This production externality will be key in generating larger growth rates, a decreasing physical capital–output ratio at the beginning of the transition after the destruction of physical capital, and a saving rate that reaches its maximum value later than in a model without social capital.

Eq. (8) describes the intratemporal allocation between consumption and investment in social capital while taking into account habit formation. This condition will also play an important role in our results and requires some further comments. The intratemporal allocation is influenced by the fact that social capital is a durable good that enters the utility function. We can rewrite expression (8) as

$$U_{c_t} - \beta(1-\eta)U_{c_{t+1}} = \beta U_{e_{t+1}}, \tag{9}$$

where U_x represents the marginal utility of variable x. Since social capital is a durable good, the latter will have an impact on the intertemporal allocation due to the presence of the term $U_{c_{t+1}}$. If social capital fully depreciates each period, i.e., $\eta = 1$, the marginal rate of substitution between social capital and consumption is a constant, while it becomes variable when $\eta \neq 1$. In the present case, the marginal rate of substitution is always smaller than in a model where social capital is not a stock but a flow variable, and this translates into a larger social capital–consumption ratio. The state variable nature of social capital induces agents to invest relatively more in the latter at the expense of consumption and moderates in turn the future stock of habits. This outcome will be important in adjusting the hump of the saving rate by not allowing habits to grow too fast as in the standard model without social capital. The depreciation rate of social capital η is thus fundamental for our results and an exogenous increase in the latter (other things being equal) induces a substitution from social capital towards consumption.[3]

We can get some further insights on the working of the model by combining expressions (7) and (8) in order to obtain the marginal rate of substitution between future consumption and future social capital:

$$\frac{U_{e_{t+1}}}{U_{c_{t+1}}} = \alpha A(e_{t+1})k_{t+1}^{\alpha-1} - \delta + \eta. \tag{10}$$

When the marginal productivity of physical capital is large, the agent allocates relatively more resources towards savings since future consumption is the most efficient way to generate utility gains. However, as the marginal productivity of physical capital decreases, the agent tends to increase social capital investment at the expense of physical capital accumulation. The change in the relative allocation of both types of capital provides a potential explanation concerning the hump-shaped pattern of the saving rate observed in the data.

Given the initial stocks of physical, social capital and habits, k_0, e_0 and c_{-1}, a competitive equilibrium in this economy consists of a path of prices $\{r_t, w_t\}$ and a path of allocations $\{k_t, e_t, c_t, m_t\}$ that are consistent with consumer and firm optimization and with the market clearing condition $y_t = k_{t+1} + c_t + m_t - \delta k_t$. The dynamic equilibrium is thus characterized by a set of paths $\{k_t, e_t, c_t, m_t, r_t, w_t\}$ that, given the initial conditions k_0, e_0 and c_{-1}, solves the system formed by the difference equations (1), (3), (5), (6), (7) and (8).

We next focus on the existence of a balanced growth path (BGP) equilibrium for this economy. In the present case, a BGP equilibrium is a path along which the equilibrium allocations $\{y_t, k_t, e_t, c_t, m_t\}$ either grow a constant rate or stay constant. We denote the latter case as a steady-state. By log-differentiating the production function (4), the budget constraint (3) and the law of social capital accumulation (1), we obtain that along a BGP and at a steady-state equilibrium the following conditions hold: $g_m = g_e$,

$$g_k = \left(\frac{\epsilon_A}{1-\alpha}\right)g_e,$$

[3] As explained before, at least some part of the depreciation term can be interpreted as a consequence of individuals' mobility. The model predicts that an increase in mobility tends to decrease investment in social capital which is in line with empirical evidence provided by DiPasquale and Glaeser (1999) highlighting the fact that homeowners tend to invest more in social capital.

and

$$g_c = \left[\frac{\epsilon_A}{(1-\alpha)u} - \frac{1-u}{u}\right] g_e,$$

where u is the fraction of total expenditure devoted to consumption along a BGP or at a steady-state equilibrium. The next proposition focuses on the existence and stability of the BGP equilibria of our competitive economy.

Proposition 1.

(i) If $\epsilon_A + \alpha < 1$, there is a unique positive steady-state which is locally stable.
(ii) If $\epsilon_A + \alpha > 1$, there is a unique positive steady-state which is unstable.
(iii) If $\epsilon_A + \alpha = 1$, there is a unique BGP equilibrium where $g_e > 1$ or $g_e < 1$.

Proof. See Appendix B □

From now on we will focus on the case where $\epsilon_A + \alpha < 1$ guaranteeing the existence of a unique positive and locally stable steady-state. The cases where $\epsilon_A + \alpha \geq 1$ are ruled out for several reasons. First, in the case where $\epsilon_A + \alpha > 1$, the unique positive steady-state is unstable. Second, these cases require an elasticity of social capital in the production function that is too large given available empirical evidence. Third, the case where $\epsilon_A + \alpha = 1$ rules out decreasing returns and is thus unable to replicate accurately the dynamic pattern of the physical capital–output ratio.

Assumption A. $\epsilon_A + \alpha < 1$.

The steady-state of our competitive economy when Assumption A holds is then characterized by the following set of equations:

$$\beta\left[1 + \alpha A(e)k^{\alpha-1} - \delta\right] = 1, \tag{11}$$

$$\frac{\theta(1-\beta\rho_c)[1-\beta(1-\eta)]}{(1-\theta)(1-\rho_c)c} = \frac{\beta\phi}{(1-\rho_e)e}, \tag{12}$$

$$A(e)k^{\alpha} - \delta k = c + m, \tag{13}$$

and

$$e\eta = \phi m. \tag{14}$$

Our economy with social capital converges to the modified golden rule but the steady-state physical capital stock is affected by the presence of social capital externalities in production. Given a set of parameters, the steady-state equations define ratios of state variables towards which the economy will converge. For example, expression (12) defines the stationary value of consumption–social capital ratio. By combining the steady-state equations we can also explicitly derive the steady-state physical–social capital ratio:

$$\frac{k}{e} = \frac{\alpha\{\theta(1-\beta\rho_c)[1-\beta(1-\eta)](1-\rho_e) + (1-\theta)\beta(1-\rho_c)\eta\}}{\phi(1-\theta)(1-\rho_c)\{1-\beta[1-\delta(1-\alpha)]\}}.$$

An interesting feature of our model is that the steady-state allocation depends on the habit parameter ρ_c, which is not the case in a model without social capital. An exogenous increase in the habit formation parameter implies in turn an increase in the physical–social capital ratio. When the habit formation parameter increases, the representative agent decides to invest relatively more in physical capital in order to satisfy future habits. This effect is present even in the long-run contrary to a model without social capital, where the steady-state physical capital stock is independent of the habit formation parameter.

3. Numerical analysis

Our objective in this section is to illustrate how our mechanism for explaining the dynamic recovery from capital destruction caused by conflicts operates. To this end, we focus on the European reconstruction process after World War II. We simulate numerically our theoretical model and compare its implications to a model without social capital but with a similar structure concerning habit formation. In the latter case, given $k_0 > 0$ and $c_{-1} > 0$, the economy is fully described by expressions (3) and (7), where $\epsilon_A = m_t = 0$. We will show that, by comparing with the latter, our framework is able to replicate more accurately the dynamic transition of European countries during the post-war period.

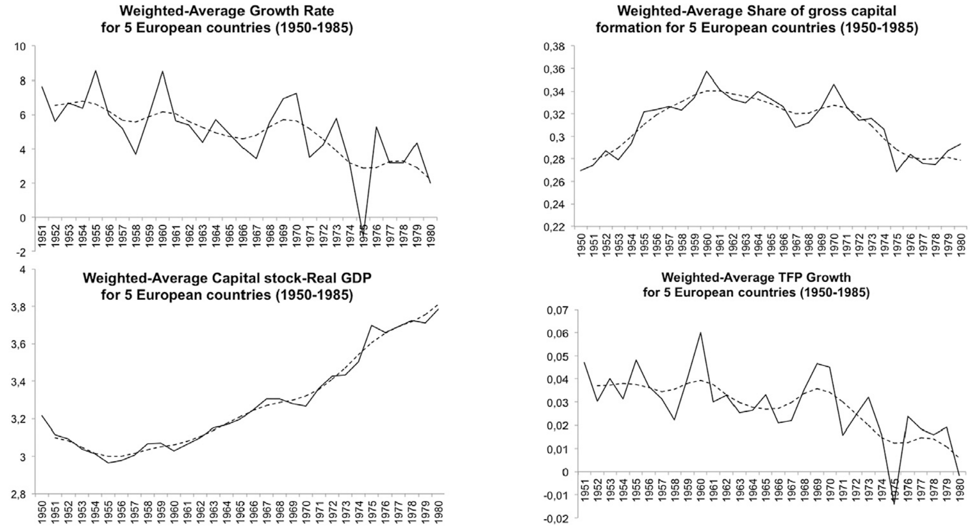

Fig. 1. Evolution of key economic variables for five European economies (1950–1980).

3.1. *Evidence from the European reconstruction*

As expressed in the introduction, the European post-war growth experience is one of the best source of the facts on recovering from a capital destruction during a conflict. Hence, we will make use these facts to calibrate our model and to measure the accuracy of our economic mechanism.

The main features of the European post-war reconstruction can be seen from Fig. 1. We present there weighted averages of the output growth rate, the saving rate, the output–capital ratio and the growth rate of measured total factor productivity (TFP, henceforth) for five European economies between 1950 and 1980 (France, Germany, Italy, Austria and the Netherlands).[4] The figure presents both the actual data as well as detrended variables using moving averages.

There are some characteristics of the data that are worth mentioning. First, large growth rates are persistent and last until the beginning of the 1970's. Second, the saving rate reaches its maximum value after more than a decade and the magnitude of the hump is around 6%. Third, the physical capital–output ratio starts to increase around 1955 and exhibits a clear U-shaped pattern. Finally, we observe that the measured TFP growth rate decreased by $87,5\%$, from 4% in 1950 to 0.5% in 1980. These characteristics are the ones that we will use in order to assess the capacity of our model to generate dynamic patterns in accordance with empirical evidence.

3.2. *Calibration*

To proceed with our numerical analysis, we first need to choose a specific functional form concerning social capital externalities in production. We consider that total factor productivity takes the following form:

$$A(e_t) = \hat{A} e_t^{\gamma}, \tag{15}$$

where $\gamma \in (0,1)$ is the intensity of the external effect of average social capital on aggregate productivity. Under this parametrization, the elasticity of total factor productivity with respect to social capital is $\epsilon_A = \gamma$.

The parameters are calibrated in order to reproduce some of the empirical facts of developed economies. Table 1 provides the benchmark values of the parameters that we use in our numerical simulations. First, we fix the parameters that are common in the two economies that we consider: the *benchmark economy* with social capital and habit formation, and a *counterfactual economy* without social capital but with habit formation. The scaling parameter $\hat{A}$ governing total factor productivity is arbitrarily set a 3. Following the RBC literature, we set the discount factor β, the depreciation rate of the physical capital stock δ and the elasticity of physical capital in the production function α to 0.96, 0.1 and 0.33, respectively, in order to obtain a steady-state physical capital–output ratio of 2.3, a stationary investment–physical capital ratio equal to 0.1, and a labor income share in GDP of 67%. The stationary values of these aggregate figures neither depend on the parameters governing the process of habit formation nor on those parameters determining the influence of social capital. Therefore, the values of the previous parameters are the same in all the economies that we will consider in order to obtain comparable results.

[4] As pointed out by Alvarez-Cuadrado (2008), these five economies are among the ones most affected by the conflict. The data is taken from the Penn World Table 9.0. In particular, the measured TFP corresponds to the variable *rtfpna*, which derives TFP at constant 2011 prices.

Table 1
Values for the parameters.

Technologies						Preferences			
$\hat{A}$	α	γ	δ	ϕ	η	β	θ	ρ_c	ρ_e
3	0.33	0.35	0.1	0.9	0.6	0.96	0.6	0.8	0.3

Second, we choose the parameter ρ_c governing the process of habit formation. In particular, we set a value of 0.8 which is the one used by Constantinides (1990) and Boldrin et al. (2001) in their respective works on asset pricing. Moreover, this value is in line with empirical evidence provided by Fuhrer (2000) and Fuhrer and Klein (2006). We use this particular value in the two economies we consider: the benchmark economy and the counterfactual economy.

Finally, we calibrate the parameters that determine the accumulation and the economic influence of social capital: θ, γ, ρ_e, ϕ and η. We start by discussing the values of the parameters driving the accumulation of social capital. The parameter governing the impact of investment in social capital ϕ is set at 0.9. We expect that given its intangible nature and the mobility of individuals, the depreciation rate of social capital is larger than the one of physical capital. Ishise and Sawada (2009) try to estimate the latter and conclude that the depreciation rate of social capital is at least of 10% and is indeed larger than the one of physical capital. However, the European post-war period is characterized by large internal migrations inducing probably important depreciation rates of social capital. At this point, we must distinguish between two different types of spatial mobility of population: (a) migrations during the war due to the conflict itself (i.e., geographical displacement of refugees), which we treat as a negative shock of the conflict on the social capital stock; or (b), internal migrations due to institutional and technological changes that occurred during the post-war period, which, as was explained before, we have simplified by considering them as an engine of social capital depreciation. For instance, Olson (1982) argues that the war broke preexisting ties that kept people in the rural areas and simulated intense migrations during the post-war period. The specific cases of France and Germany have been documented by Saint-Paul (1993) and Giersch et al. (1993) respectively. We then choose to set $\eta = 0.6$ in our baseline calibration. In order to get an idea of what this choice represents, we compute the half-life with which the stock of social capital would adjust to a permanent change in social capital investment. Suppose that the representative agent reduces permanently social capital investment to zero, half of the social capital stock would be depleted in roughly nine months.[5]

One of the key parameters governing the dynamics of the economy is γ which controls the magnitude of the production externality. Despite the difficulty to define properly social capital, there has been a few attempts to estimate the magnitude of social capital externalities in production. Using social development indexes constructed in the early 1960's, Temple and Johnson (1998) estimate that differences in such indexes can explain between 10 and 40% of the variation in growth rates for developing countries. In addition, the authors find that a part of the impact acts via total factor productivity. Fafchamps and Minten (2002) use data on agricultural traders in Madagascar to estimate the impact of social network capital on productivity and find that the effect is large. For example, a doubling of the number of known traders and potential lenders raises gross margins by 18-22%. Using an augmented Solow model, Ishise and Sawada (2009) try to estimate the aggregate returns to social capital and obtain values between 10% and 20%. In order to estimate the latter, the authors focus mainly on social connectivity and information sharing. While these are important steps forward, we think that our production externality includes other positive effects of social capital such as the accumulation of human capital or the signaling device used to recruit specific workers. If these elements are important, it is probable that the aggregate returns to social capital are relatively large and we set $\gamma = 0.35$. As expressed by Sequeira and Ferreira-Lopes (2011), this value is in line with evidence provided by Whiteley (2000) who identifies an effect of social capital as big as the one of human capital and the World Bank (2006) which estimates a share of intangible capital (including both human and social capital) around 78%. In addition, as will be discussed in the following, this value generates initial gross interest rates that can be considered as reasonable.

We now focus on the parameters related to social capital in the utility function. The parameter governing aspirations in social capital ρ_e is set at 0.3 which is the value estimated by Alvarez-Cuadrado et al. (2016) concerning consumption envy across individuals. This value is also in line with the estimates provided by Maurer and Meier (2008) as well as with the ones from the experimental literature (see Alpizar et al., 2005).

Concerning the respective weights of consumption and social capital in the utility function, these are not straightforward to choose since few papers have focused on a model with both goods. Unfortunately, we can neither find evidence of the effort devoted to the investment in social capital at the post-war time. To overcome this limitation, and to get some insight about the magnitude of this investment, we use data from the American Time Use Survey (ATUS) of 2018 to compute an estimate of time spent accumulating social capital.[6] A better option would be to access data on time use after the war but to the best of our knowledge, such data is not available. However, the ATUS survey has been conducted annually since 2003 and the time spent of different activities is relatively constant from one year to another. We first compute the amount of daily hours dedicated to working activities which is around four. We then list non-working activities with a social component (inducing contact with others) and interpret the latter as time spent accumulating social capital.[7] Computing daily hours spent on those activities gives us a value around two. This implies that

[5] Note that the half-life convergence is given by $t_{1/2} = -\ln 2/\ln(1-\eta) = 0.75$ if we set $\eta = 0.6$.

[6] U.S. Bureau of Labor Statistics (2018).

[7] The activities surveyed at ATUS that we consider that contribute to increase the stock of social capital include: *Caring of non-household members*; *Educational activities*; *Organizational and civic activities*; *Socializing, relaxing and leisure*; *Sports, exercise and recreation*; *Telephone calls, mail and e-mail.*

for each working hour individuals dedicate half an hour to social capital accumulation. Since we have normalized the labor supply to unity, we are then able to derive a value of $m/w = 0.5$. Obviously, this figure should be taken with caution because it does not correspond to evidence from the post-war period and, moreover, it was obtained without considering the market goods used in increasing social capital. However, this is the best estimate that we can obtain at this time.

We now use this estimation of m/w to set the value of the utility weight θ by using the following procedure. On the one hand, we use the stationary feasibility constraint at the steady state (13) to obtain

$$\frac{1}{1-\alpha} = \frac{c+m+\delta k}{w},$$

where

$$\frac{\delta k}{w} = \frac{\alpha\beta\delta}{(1-\alpha)(1+\beta\delta)},$$

which is derived by combining the steady-state condition (11) with (6) evaluated at the steady-state equilibrium. Since $m/w = 0.5$, the previous condition in turn pins down a consumption–wage ratio c/w equal to 0.65. On the other hand, combining the steady-state conditions (12) and (14), we obtain

$$\frac{m}{c} = \frac{\beta\eta(1-\theta)(1-\rho_c)}{\theta(1-\beta\rho_c)[1-\beta(1-\eta)](1-\rho_e)}. \tag{16}$$

Since $m/c = 0.77$ and given the values assigned to the rest of the parameters, the expression provides a value for θ around 0.6. For the representative agent, consumption is thus slightly more important than social capital.

3.3. Initial conditions

We need to fix the initial values for our three state variables: the physical capital stock, the social capital stock as well as the consumption reference. For most European countries, World War II was responsible for a large destruction of the physical capital stock. The available evidence for war economies suggests a loss between 30% and 90% of the pre-war physical capital stock depending on the calculation method (Alvarez-Cuadrado, 2008). We then choose an initial value corresponding to 50% of the steady-state physical capital stock as in Alvarez-Cuadrado (2008).

Concerning social capital, as pointed in the introduction, empirical evidence suggests that the latter is also heavily affected by war and civil conflict (Becchetti et al., 2013; De Luca and Verpoorten, 2015). We suppose that the loss is similar to the one experienced by physical capital and fix an initial value corresponding to 50% of the steady-state social capital stock.

Finally, the initial reference for consumption habits is not easy to determine due to the lack of available data concerning consumption levels during the war. We know that the reference must be relatively large in order to generate an increasing saving rate at the beginning of the transition. In order to compare the model with and without social capital we choose to set an initial habit stock corresponding to 80% of its steady-state value. This is slightly below the one used by Alvarez-Cuadrado (2008) who estimates an initial habit stock corresponding to 90% of its steady-state value.

3.4. Comparison of both economies

In this section, we simulate the dynamic paths of two models. The first one labeled the counterfactual economy is an economy without social capital but with habit formation. The second one labeled the benchmark economy is our economy with both social capital and habit formation. As was mentioned before, the two economies were calibrated in the same way in order to be comparable implying that they exhibit the same stationary values of the saving rate and the physical capital–output ratio. We are interested in the dynamic behavior of the economies immediately after the destruction of physical capital. For that reason, we have not considered any source of sustainable long-run growth. Therefore, the simulated growth rate must be understood as the deviation from trend when compared with the observed growth rate in the data. In this sense, we should also note that the RBC literature estimates a growth rate around 2% along the trend for advanced economies.

The results of our simulations are presented in Fig. 2. The growth rate of output in our benchmark economy with social capital follows a hump-shaped pattern while the one of the counterfactual economy is at first larger and monotonically decreases. More important, growth is more persistent in the model with social capital since the latter is significantly larger than zero after 25 periods contrary to the model without social capital. The difference between both economies is the presence of social capital externalities in production which increase total factor productivity in the benchmark economy. The maximum growth rate generated by the model takes values slightly above 2.3%. While it is clear from Fig. 1 that at the beginning of the post-war transition most countries experienced per capita growth rates that are much larger than 2.3%, our model only takes into account the impact of physical capital deepening and social capital externalities. As mentioned before, we have abstracted from considering a positive trend on the growth rate. If we introduce additionally an exogenous TFP growth, our output growth rates are already more in line with empirical estimates.

Concerning the physical capital–output ratio, the counterfactual economy exhibits a monotonically increasing ratio as it is usual in the neoclassical growth model. Our benchmark economy is able to generate a slightly decreasing physical capital–output ratio at the beginning of the transition as suggested by Fig. 1. After this initial decrease, the ratio increases monotonically towards the steady-state. The initial behavior is due to a large accumulation of social capital at the beginning of the transition implying that

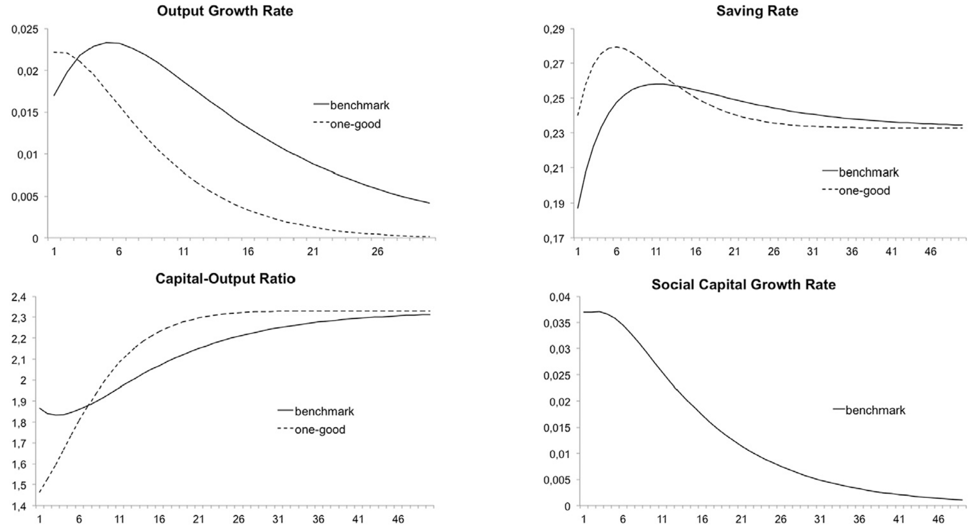

Fig. 2. Equilibrium paths of key economic variables.

output grows faster than physical capital. However, this behavior is only temporary and after a few periods, physical capital starts to grow faster than output as in the economy without social capital.

Finally, the behavior of the saving rate is clearly different in both models. Comparing with the counterfactual economy, the transition in our benchmark economy is characterized by a smaller hump and a maximum value that is reached later in time. The magnitude of the hump in our economy with social capital takes a value around 7% which seems in accordance with empirical evidence provided in Fig. 1. As explained before, the incentive to accumulate social capital modifies the intertemporal allocation of consumption by moderating the increase in the habit stock. The magnitude of the hump is a direct consequence of the latter since when the habit stock grows faster, the agent needs a larger increase in savings in order to be able to satisfy future consumption references. The saving rate of our model reaches its maximum value later due to the positive impact of social capital on the rate of return. In both models, at some point during the transition, the neoclassical effect due to a decreasing marginal productivity of physical capital starts to dominate the habit formation effect inducing a decrease in the saving rate. The presence of social capital in the production function delays this outcome and the neoclassical effect only starts to dominate after more than a decade as suggested by empirical evidence.

It is also interesting to focus on the growth rate of social capital. As explained in the introduction, while war and civic conflict affect heavily social capital, empirical evidence suggests that the latter recovers relatively fast after the end of the conflict. Our simulation results deliver a similar outcome with large growth rates concerning social capital at the beginning of the transition. These large growth rates play several roles in our framework: they imply larger output growth rates, delay the decrease in the marginal productivity of physical capital and are the reason why the physical capital–output ratio decreases at the beginning of the transition. This indicates that a different input that is not affected so much by the conflict might not be able to play such a role. For example, human capital which was not subject to destruction levels equivalent to those of physical capital (see for example, Crafts and Toniolo, 1996; Harrison, 2000) might not be able to fulfill this task.

A part of our results are driven by the impact of social capital on aggregate productivity which derives directly from the elasticity of social capital in the production function γ. On the one hand, given the production function (4), social capital fully drives the TFP, so that the growth rate of the latter variable at period t is given by $\gamma(e_t/e_{t-1})$. Hence, the growth rate of TFP replicates the shape of the path followed by the growth rate of social capital along the transition. Taking the values of the latter growth rate from Fig. 2, we obtain that the growth rate of TFP decreases by 85.39% during the first 30 periods of the transition. This figure is slightly smaller than the 87.5% reduction that we measured in the data. However, we believe that the model makes a good job in replicating the measured TFP, which in reality is also driven by other engines.[8]

On the other hand, social capital partially determines the marginal productivity of physical capital. Therefore, the value taken by the gross rate of return in our simulation exercise is also a good way to evaluate if this choice is reasonable. In the benchmark economy, the gross rate of return reaches a maximum value around 18% after a few periods before declining monotonically towards its steady-state value of 14%. King and Rebelo (1993) argue that using a standard neoclassical growth model in order to explain the post-war reconstruction would imply extremely high and unrealistic real interest rates. The introduction of habit formation and social capital in our framework allows to reduce the value of real interest rates at the beginning of the transition. However, a sufficiently large value of γ is also required in order to generate initial real interest rates that are not too small.

[8] We cannot compare the levels of TFP growth rates in the simulations with those in the data because, as was mentioned before, we have not considered any source of long-run sustainable growth.

Table 2
Stable eigenvalues.

Benchmark economy	Counterfactual economy
0.3103	$0.8418 + 0.065\ i$
0.8265	$0.8418 - 0.065\ i$
0.9191	

A last method to evaluate the capacity of our framework in replicating accurately the dynamic transition following the conflict is to focus on the speed of convergence of the model. On the empirical side, Islam (1995) and Caselli et al. (1996) estimate that the speed of convergence is close to 9%. We have shown that the benchmark model is characterized by local-stability and the same applies to the counterfactual economy. In our benchmark economy, there are three state variables implying that the speed of convergence of any endogenous variable is a weighted function of the three eigenvalues inside the unit circle. The numerical values of these three stable eigenvalues are given in Table 2. Over time, the weight of the smaller eigenvalues declines so that the largest one inside the unit circle describes the asymptotic value of the speed of convergence. In our benchmark case, the largest eigenvalue inside the unit circle is equal to 0.9191 implying an asymptotic speed of convergence equal to 8.4% (since $\ln(0.9191) = -0.084$), which is in line with empirical evidence. In the counterfactual economy, there are two state variables and the eigenvalues inside the unit circle come in conjugate pairs. In such a case, an appropriate measure of the speed of convergence can be obtained through the modulus of the root which is equal to 0.8443. This in turn implies a speed of convergence equal to 17% which is way above any empirical estimate.

The introduction of social capital in our model tends to moderate the increase in the habit stock and the decrease in the marginal productivity of physical capital. This additional sluggishness explains why the economy tends to converge at a smaller speed which is much more in line with empirical evidence. Our results also suggest that our parametrization is fairly consistent with empirical evidence despite the lack of data concerning some of the parameters related to social capital.

The importance of social capital in our framework leads to the question of the correlation between the latter, growth and the saving rate. Our model is in line with the one of Carroll et al. (2000) which suggests that large growth rates imply in turn large saving rates. The fact that the output growth rate reaches its maximum value before the saving rate and that both variables behave qualitatively in a similar way suggests that this is indeed the case. A related and important question is whether or not fast social capital accumulation implies large growth rates and by extension large saving rates. While we did not proceed to a formal statistical test, our simulations seem to suggest that is this indeed the case with a decrease in social capital growth that precedes the one of output.

3.5. Sensitivity analysis

In this section, we will proceed with three types of sensitivity analysis. The first one will focus on the importance of some key parameters for the proposed mechanism, the second will introduce habit persistence into our benchmark model while the third one will take into account the potential impact of the Marshall plan on our results.

3.5.1. Robustness to the variation of parameters

We now analyze how sensible are the dynamics of the benchmark economy to changes in the parameters that affect the accumulation and the economic influence of social capital. More precisely, we study the effects of introducing one-by-one variations in the values of θ, ρ_e, ϕ, η and γ from their benchmark values. Remember that the first two parameters determine the direct satisfaction effect of social capital, the second two drive its accumulation and, finally, the last one guides its impact on aggregate productivity.

We separately simulate the dynamics of our economy by considering the following alternative values for those parameters: $\theta = 0.8$, $\rho_e = 0.6$, $\phi = 0.6$, $\eta = 0.4$ and $\gamma = 0.25$. The results of this sensitivity analysis can be summarized as follows. First, the hump-shape of the saving rate still emerges in all the cases, although the magnitude of the hump and the number of periods the rate takes in reaching the maximum values are quite sensitive. While benchmark values of 7% and 11 periods are robust to the variations in ϕ and η, they experiment significant changes when we vary θ, ρ_e and γ. In particular, the magnitude of the hump and the number of periods needed to reach the maximum value of the saving rate are: 11% and 13 periods when $\theta = 0.8$; 4% and 9 periods when $\rho_e = 0.6$; and 5% and 8 periods when $\gamma = 0.25$.

Second, the capital–output ratio maintains the benchmark U-shape for all the alternative values. Furthermore, the length of the initial reduction is smaller under the counterfactual values of ρ_e and γ, while this reduction is larger for the counterfactual value of θ. However, this initial decrease in the capital–output ratio is basically insensible to the considered variations in ϕ, η.

Third, the growth rate of output maintains the hump-shaped pattern exhibited in the benchmark economy except for the counterfactual value of γ. In the latter case the initial value of the growth rate is 2.6%, and then it monotonically decreases to zero. In fact, we have obtained that 0.25 is the threshold value of γ above which the growth rate of output exhibits the hump-shaped path derived in the benchmark economy. For values below this threshold, the growth rate is monotonously decreasing along the entire transitional dynamics. However, as was mentioned before, the hump-shaped path of the saving rate emerges for any value of $\gamma > 0$, i.e., there is not a minimum value of this parameter required to replicate the hump-shaped pattern observed in the data for the saving rate.[9] Therefore, production externalities from social capital only determine the maximum value of the hump, as well as, the number of periods that the saving rate takes in reaching this value. These conclusions highlight the role of production externalities in the proposed mechanism of dynamic adjustment. These externalities compensate the standard diminishing returns to capital, so that the destruction of physical capital does not cause a large investment in this capital if there is also a destruction of social capital. In this case, the positive impact of the reduction in physical capital on the marginal productivity of this capital is offset by the negative effect of the destruction of social capital on TFP. Furthermore, output grows more than physical capital in the first periods of the adjustment process since the investment in social capital is larger than the investment in physical capital, which leads a large growth rate of TFP. Therefore, production externalities are also crucial to obtain an initial decrease in the capital–output ratio.

Finally, contrary to the behavior in the benchmark economy, the growth rate of social capital exhibits a hump-shaped pattern when we consider the counterfactual values of θ and η. This alternative behavior then implies also a hump-shaped pattern of the TFP that is not validated by the measured TFP from data that we plot in Fig. 1. Obviously, we might recover the monotonic decreasing path in these counterfactual scenarios by reducing the deviation of the initial value of the social capital stock from its stationary value.

3.5.2. *The model with habit persistence*

In this subsection, we introduce habit persistence into our framework in order to study the influence of a low degree of habit persistence on our results. The utility function now becomes

$$U = \sum_{t=0}^{\infty} \beta^t [\theta \ln(c_t - \rho_c z_t) + (1-\theta)\ln(e_t - \rho_e \bar{e}_{t-1})], \tag{17}$$

where z_t represents the habit reference stock and the dynamics of the latter are given by

$$z_t = \rho z_{t-1} + (1-\rho) c_{t-1}, \tag{18}$$

with $\rho \in [0, \infty)$. The reference stock in t is a combination between the reference stock and consumption in $t-1$. When ρ is small, persistence is low and the reference is mainly built from last period's consumption experience. To solve the consumer's optimization problem in this case, we can iterate backward the habit stock z_t by using (18), so that we can rewrite the utility function (17) as:

$$U = \sum_{t=0}^{\infty} \beta^t \left\{ \begin{array}{c} \theta \ln \left[c_t - \rho_c (1-\rho) \sum_{i=1}^{\infty} \rho^{i-1} c_{t-i} \right] \\ + (1-\theta) \ln(e_t - \rho_e \bar{e}_{t-1}) \end{array} \right\},$$

and maximize the latter subject to the budget constraint (3) and the law of social capital accumulation (1).

We first compute the marginal utilities of consumption in t and $t+1$:

$$U_{c_t} = \frac{\theta}{c_t - \rho_c z_t} - \sum_{i=1}^{\infty} \frac{\beta^i \theta \rho_c (1-\rho)\rho^{i-1}}{c_{t+i} - \rho_c z_{t+i}},$$

and

$$U_{c_{t+1}} = \frac{\theta}{c_{t+1} - \rho_c z_{t+1}} - \sum_{i=1}^{\infty} \frac{\beta^i \theta \rho_c (1-\rho)\rho^{i-1}}{c_{t+1+i} - \rho_c z_{t+1+i}}.$$

Given initial conditions, k_0, e_0 and $z_0 > 0$, the competitive equilibrium of the economy with habit persistence (i.e., $\rho \neq 0$) is fully described by the dynamic system composed of difference equations (1), (3), (18)

$$U_{c_t} = \beta \left(1 + \alpha A(e_{t+1}) k_{t+1}^{\alpha-1} - \delta\right) U_{c_{t+1}}, \tag{19}$$

and

$$U_{c_t} = \frac{\beta(1-\theta)\phi}{e_{t+1} - \rho_e e_t} + \beta(1-\eta) U_{c_{t+1}}. \tag{20}$$

The steady state is characterized by the following set of equations: $z = c$, $e\eta = \phi m$,

$$\beta \left[1 + \alpha A(e) k^{\alpha-1} - \delta\right] = 1,$$

$$\frac{\theta[1-\beta(1-b)][1-\rho_c(1-\rho)\sum_{i=1}^{\infty}\beta^i \rho^{i-1}]}{(1-\theta)(1-\rho_c)c} = \frac{\beta\phi}{(1-\rho_e)e},$$

and

$$A(e)k^{\alpha} - \delta k = c + m.$$

[9] For instance, we still obtain a hump-shaped saving rate when $\gamma = 0.01$, although the magnitude of the hump is only of 0.4% and the maximum value of the rate is reached in 3 periods.

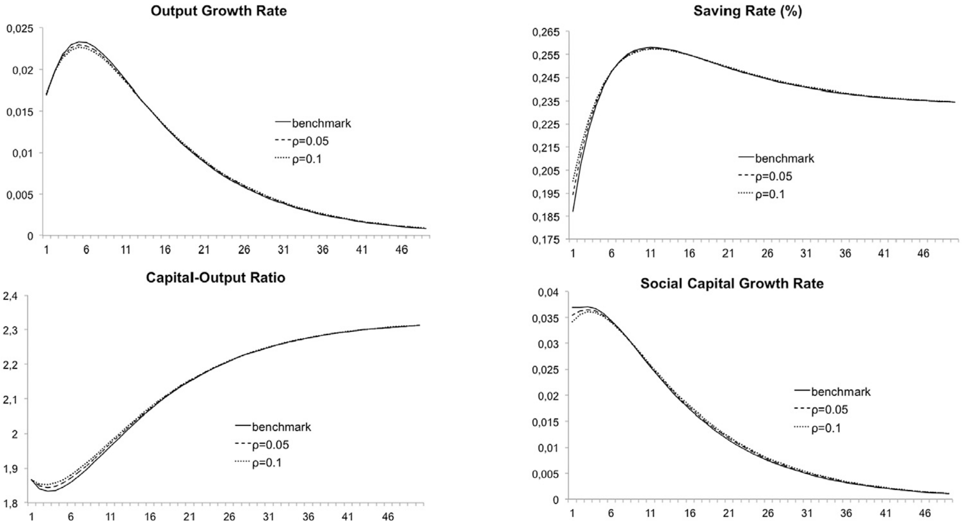

Fig. 3. Dynamic effects of habit persistence.

At the steady-state, the main difference between the two models concerns the consumption–social capital ratio since the latter depends explicitly on the habit persistence parameter. Comparing the intratemporal allocation in both models we can conclude that the consumption–social capital ratio is larger in the model with habit persistence if and only if

$$(1-\rho)\sum_{i=1}^{\infty}(\beta\rho)^{i-1} < 1,$$

or equivalently

$$\frac{1-\rho}{1-\beta\rho} < 1,$$

which is always the case since $\beta < 1$. This implies as well a larger physical–social capital ratio in the economy with habit persistence. Given the minor changes implied by habit persistence, it is straightforward to show that there is once again a unique positive steady-state in this case.

In order to simulate this new model, we keep the same values for the parameters but in addition we need to fix the value of the habit persistence parameter ρ. Using quarterly data, Fuhrer (2000) estimates that ρ takes values between 0.0015 and 0.052 depending on the estimation method. We will consider two possible values for ρ that maintain a low level of persistence: 0.05 and 0.1. In order to get an idea of what this value represents, we follow the approach of Carroll et al. (2000) and compute the half-life with which habits would adjust toward a permanent change in consumption. When $\rho = 0.05$, this is approximately 3 months (i.e., $t_{1/2} = -\ln 2/\ln\rho = 0.23$), while when $\rho = 0.1$ this is approximately 4 months.

The results of our simulations are presented in Fig. 3 which includes the dynamic paths for the three economies that only differ in terms of the habit persistence parameter. The major changes concern the physical capital–output ratio and the saving rate. On one hand, the initial decrease of the physical capital–output ratio observed in the benchmark case tends to disappear when we increase the habit persistence parameter. On the other hand, the initial saving rate tends to increase when we introduce habit persistence in the model. With habit persistence the negative impact of an increase in current consumption on intertemporal utility is larger since the effect is delayed in time and the agent prefers to increase savings at the beginning of the transition. We can finally notice that the maximum growth rates of output and social capital are smaller than in the benchmark case. Given these numerical results, we tend to conclude that including habit persistence in the present model does not seem to increase the accuracy of the recovery dynamics.

We finally compare our benchmark case to a model without social capital but with a degree of persistence in habits sufficiently large to reproduce the stylized facts of the post-war transition. In this case, given k_0 and $z_0 > 0$, the economy is fully described by expressions (3), (18) and (19) with $\epsilon_A = m_t = 0$. We follow Alvarez-Cuadrado (2008) and set $\rho = 0.7$ implying a half-life close to two years.[10] Fig. 4 presents the dynamic paths of our key variables for both economies.

Once again, the absence of social capital in the counterfactual economy implies that the growth rate of output is less persistent in this case. Concerning the saving rate, the counterfactual economy exhibits an initial saving rate that is larger since the representative agent does not need to invest resources in social capital. However, the magnitude of the hump is relatively small compared to

[10] Alvarez-Cuadrado (2008) focuses on a continuous time framework and sets $\rho = 0.35$. The latter being equivalent to $\rho = 0.7$ in discrete time.

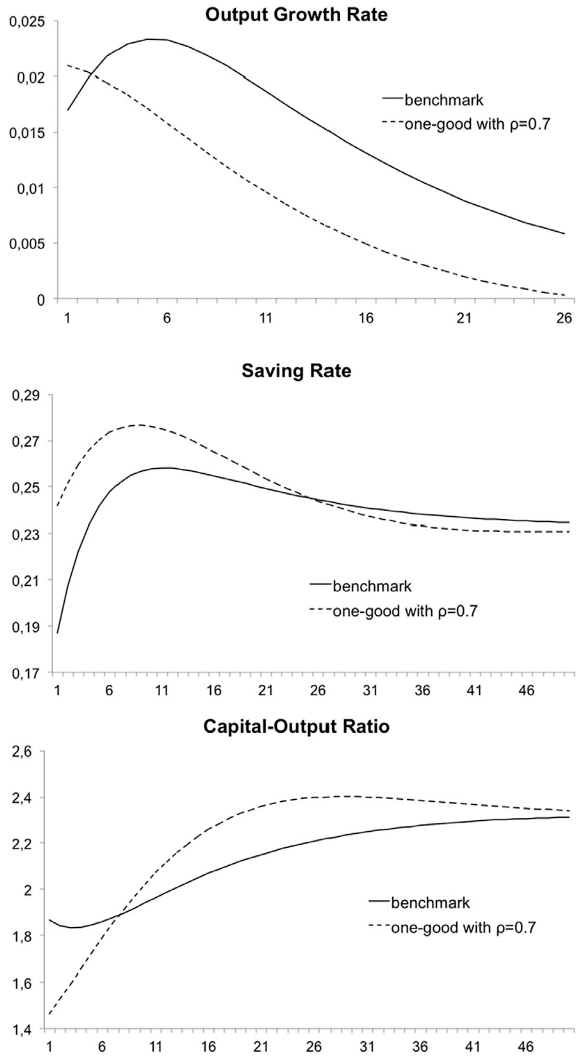

Fig. 4. Benchmark economy vs. an economy without social capital and with large habit persistence.

the data with a value around 2%. Moreover, the absence of social capital externalities in production implies that the impact of a decreasing marginal productivity of physical capital starts to dominate sooner and the decrease in the saving rate is sharper than in the benchmark case. Finally, due to the absence of social capital, the physical capital–output ratio is monotonically increasing in the counterfactual economy. Moreover, the pattern taken by the latter seems to be in contradiction with the data presented in Fig. 1.

Comparing both frameworks, we would tend to conclude that the model with social capital is more efficient in replicating accurately the post-war reconstruction dynamics of European countries.

3.5.3. The Marshall plan

Several authors have highlighted the importance of the Marshall plan and the public provision of infrastructures as key determinants of the post-war European recovery.[11] In this subsection, we introduce the Marshall plan in our framework and analyze the influence of the latter on our results. From 1948 to 1951, the Marshall plan accounted for 2.5% of the GDP of the recipient economies and was mainly directed towards public enterprises. In order to take into account the importance of this foreign aid, we introduce productive public spending following Barro (1990) in our model. The production function takes the new form:

$$f(k_t, e_t, g_t) = A(\overline{e}_t) g_t^{\zeta} k_t^{\alpha}, \tag{21}$$

[11] See De Long and Eichengreen (1991) for an exhaustive review of this literature.

where g_t is the amount of productive public capital and $\zeta \in (0,1)$ is the output elasticity of public capital. Following Alvarez-Cuadrado and Pintea (2009), the Marshall plan takes the form of a temporary transfer and we model the latter as a fraction of output, $x_t y_t$. In addition, we consider that a percentage of the transfer, ξ, is tied to the provision of public capital while the rest is allocated as a pure transfer, $x_t(1-\xi)y_t$. The government finances its expenditures from two sources: the proportion of the Marshall plan devoted to the provision of public capital, $\xi x_t y_t$, and a lump-sum tax, T_t. Given the path of government expenditures, expressed as a fixed proportion of output τ, the lump-sum tax adjusts in order to balance the budget at every period:

$$\tau y_t = \xi x_t y_t + T_t. \tag{22}$$

The law of motion of public capital is then given by

$$g_{t+1} = \tau y_t + (1-\delta_g) g_t, \tag{23}$$

where $\delta_g \in (0,1)$ is the depreciation rate of public capital. We also need to adjust the budget constraint of the representative agent in order to take into account the pure transfer from the Marshall plan and the lump-sum tax:

$$k_{t+1} = w_t + (1+r_t)k_t + x_t(1-\xi)y_t - c_t - m_t - T_t. \tag{24}$$

Given initial conditions, k_0, e_0, c_{-1} and $g_0 > 0$, the competitive equilibrium of the economy with public capital is fully described by the dynamic system composed of difference equations (1), (7), (8), (23) and (24) where

$$r_t = \alpha A(e_t) g_t^{\zeta} k_t^{\alpha-1} - \delta,$$

and

$$w_t = (1-\alpha) A(e_t) g_t^{\zeta} k_t^{\alpha}.$$

The steady-state is characterized by the following set of equations: $x = 0$, $e\eta = \phi m$,

$$\beta\left[1 + \alpha A(e) g^{\zeta} k^{\alpha-1} - \delta\right] = 1,$$

$$\frac{\theta(1-\beta\rho_c)[1-\beta(1-\eta)]}{(1-\theta)(1-\rho_c)c} = \frac{\beta\phi}{(1-\rho_e)e},$$

$$A(e) g^{\zeta} k^{\alpha} - \delta k = c + m + T,$$

and

$$T = \delta_g g.$$

In order to simulate the current model, we slightly adapt our basic calibration. We consider that the aggregate returns to both social and public capital, $\gamma + \zeta$, are set at 0.35. With this parametrization, the aggregate returns associated to the externalities in production are the same in the benchmark and the current model. The elasticity of output to public capital ζ is set at 0.1 which is in line with the estimates of Bom and Ligthart (2014). This implies that the elasticity of output to social capital γ is now equal to 0.25. The value of public spending as a share of output τ is set at 0.13 which is the long-run value used by Alvarez-Cuadrado and Pintea (2009). We suppose that the depreciation rate of public capital δ_g is the same as the one of private capital δ and is thus equal to 0.1. Finally, in accordance with the evidence provided by De Long and Eichengreen (1991), we set $\xi = 0.15$, so that one seventh of the Marshall aid is allocated to the provision of public infrastructure. The Marshall plan is operated during the first four periods in which $x = 2.5\%$ while $x = 0$ for all the remaining periods of the simulation.

The results of the simulations are presented in Fig. 5 which includes the dynamic paths for the benchmark economy and the one with public capital. The Marshall plan affects the economy by two channels: it increases directly output through public capital and relaxes the budget constraint of individual agents. Intuitively, the most important changes are observed at the beginning of the transition period when foreign aid influences our key endogenous variables. First, the output growth rate is larger during the first periods of the simulation but as soon as the impact of the plan dissipates, the persistence of the growth rate becomes slightly smaller than in the benchmark case. Second, and more important for the purpose of the paper, the introduction of public capital does not seem to alter significantly the behavior of the saving rate. Due to the presence of the Marshall plan, the saving rate reaches its maximum value sooner but this does not seem to increase the accuracy of the simulations. Third, the introduction of the plan generates a sharper decrease in the capital–output ratio. However the latter is less persistent than in the benchmark case where the capital–output ratio does not increase for a longer time period. Finally, the accumulation of social capital is substantially larger at the beginning of the transition. By relaxing the budget constraint of the individuals, the Marshall plan allows the latter to invest more resources in social capital which in turn enhances output growth.

Overall, the introduction of the Marshall plan does not seem to increase substantially the accuracy of the recovery dynamics. This result is in line with the one of Alvarez-Cuadrado and Pintea (2009) who point out the limited contribution of the plan to the reconstruction process. It must however be noted that the latter still allows us to obtain larger growth rates for output and social capital at the beginning of the transition period.

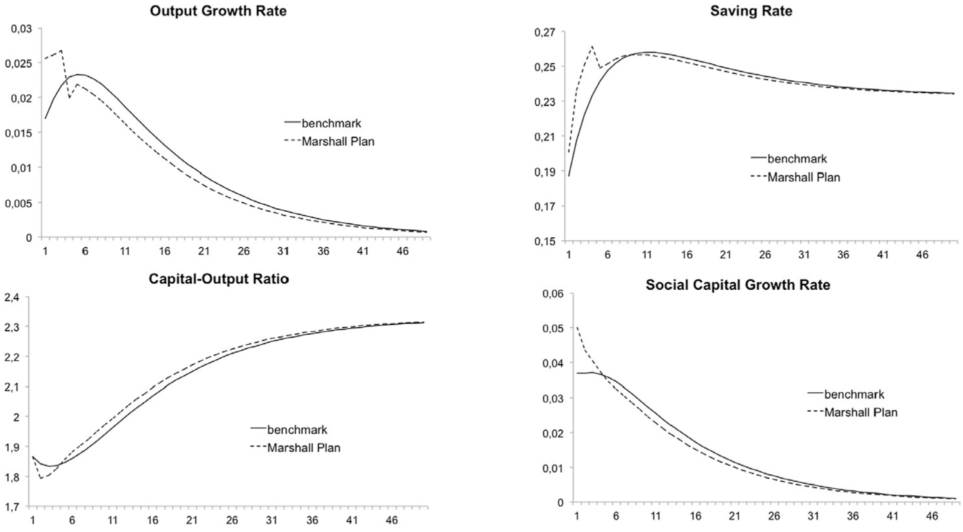

Fig. 5. Dynamic Effects of Marshall plan.

4. Conclusion

In this paper, we have studied the dynamic transition of economies which suffer from an important negative capital shock. In order to do so we have focused on the post World War II transition of European countries which has been largely documented empirically. Our theoretical model includes habit formation without persistence, the accumulation of social capital in addition to physical capital as well as social capital externalities in production. While a model relying solely on habits that depend on last period's consumption is unable to replicate accurately the non-monotonic transitional paths that characterize the post-war era, our model with social capital provides an alternative to models with habit persistence. The latter models require a high degree of persistence which seems implausible given available empirical evidence.

Our framework is able to replicate accurately the transition concerning the output growth rate, the saving rate as well as the physical capital–output ratio. Our results are driven by the fact that social capital is a state variable consumption good whose intratemporal allocation (relative to the standard consumption good) has intertemporal consequences and by the fact that the rate of return is an increasing function of the social capital stock. The destruction of social capital at levels equivalent to those of physical capital is key for our results and suggests that massive investment in social capital following the conflict might be one of the determinants of high economic growth during the post-war era.

While in the present model this large investment in social capital is entirely determined by private incentives, it seems clear that governments also play a key role in fostering social capital accumulation by implementing an institutional framework which guarantees trust and civic norms. For example, the enforcement of property and contract rights seems in this respect fundamental. In addition, we only have presented social capital as a productive consumption good but the latter could also play a role as an input in the accumulation of other types of capital such as human or financial capital. In such a case, social capital might also be a determinant of both growth and income inequality.

CRediT authorship contribution statement

Jaime Alonso-Carrera: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing. **Stéphane Bouché:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing. **Carlos de Miguel:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. The problem of the representative agent

The Lagrangian function is the following:

$$\begin{aligned}\mathcal{L} = & \sum_{t=0}^{\infty} \beta^t [\theta \ln(c_t - \rho_c c_{t-1}) + (1-\theta)\ln(e_t - \rho_e \bar{e}_{t-1})] \\ & + \sum_{t=0}^{\infty} \beta^t \lambda_t [w_t + (1+r_t)k_t - c_t - m_t - k_{t+1}] \\ & + \sum_{t=0}^{\infty} \beta^t \mu_t [(1-\eta)e_t + \phi m_t - e_{t+1}].\end{aligned}$$

The first order conditions of the maximization problem are given by

$$\frac{\partial \mathcal{L}}{\partial c_t} = \frac{\beta^t \theta}{c_t - \rho_c c_{t-1}} - \frac{\beta^{t+1}\theta\rho_c}{c_{t+1} - \rho_c c_t} - \beta^t \lambda_t = 0,$$

$$\frac{\partial \mathcal{L}}{\partial m_t} = -\beta^t \lambda_t + \phi \beta^t \mu_t = 0,$$

$$\frac{\partial \mathcal{L}}{\partial k_{t+1}} = \beta^{t+1}\lambda_{t+1}(1 + r_{t+1}) - \beta^t \lambda_t = 0,$$

and

$$\frac{\partial \mathcal{L}}{\partial e_{t+1}} = \frac{\beta^{t+1}(1-\theta)}{e_{t+1} - \rho_e e_t} + \beta^{t+1}\mu_{t+1}(1-\eta) - \beta^t \mu_t = 0,$$

while the transversality conditions for physical and social capital are given by

$$\lim_{t\to\infty} \beta^t \lambda_t k_t = 0$$

and

$$\lim_{t\to\infty} \beta^t \mu_t e_t = 0.$$

Appendix B. Proof of Proposition 1

Along a BGP equilibrium, all endogenous variables satisfy $x_{t+1} = g_x x_t$ where g_x is a constant. From expression (7), we obtain

$$g_c = \beta \left[1 + \alpha A(e_{t+1}) k_{t+1}^{\alpha-1} - \delta\right],$$

from which we derive

$$k_t = \left[\frac{\beta\alpha A(e_t)}{g_c - \beta(1-\delta)}\right]^{\frac{1}{1-\alpha}}. \tag{25}$$

From expression (1) we obtain

$$m_t = \left[\frac{g_e - (1-\eta)}{\phi}\right] e_t = \Delta e_t. \tag{26}$$

We rewrite expression (8) as

$$\left(\frac{\theta}{c_t}\right)\left[\frac{1}{1-\rho_c/g_c} - \frac{\beta(1-\eta+\rho_c)}{g_c - \rho_c} + \frac{\beta^2 \rho_c (1-\eta)}{g_c(g_c-\rho_c)}\right] = \left(\frac{1-\theta}{e_t}\right)\left(\frac{\beta\phi}{g_e - \rho_e}\right),$$

from which we deduce that

$$c_t = \Pi e_t, \tag{27}$$

where $\Pi > 0$ is a constant.

Using now expression (3) together with (25), (26) and (27), we obtain

$$\begin{aligned}&\left[\frac{\beta\alpha}{g_c - \beta(1-\delta)}\right]^{\frac{1}{1-\alpha}} \left[A(e_{t+1})^{\frac{1}{1-\alpha}} - (1-\delta)A(e_t)^{\frac{1}{1-\alpha}}\right] \\ &= \left[\frac{\beta\alpha}{g_c - \beta(1-\delta)}\right]^{\frac{\alpha}{1-\alpha}} A(e_t)^{\frac{1}{1-\alpha}} - (\Pi + \Delta)e_t,\end{aligned}$$

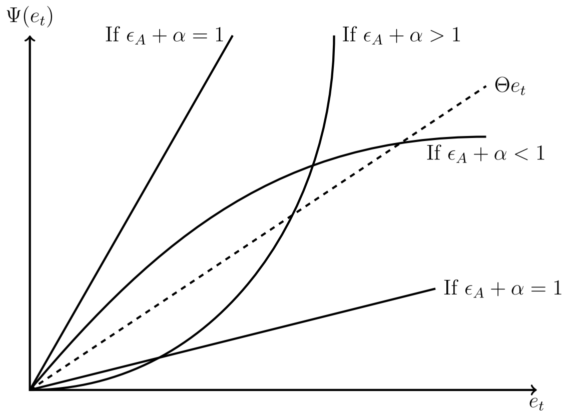

Fig. 6. Existence and stability of steady states.

which becomes

$$A(e_{t+1})^{\frac{1}{1-\alpha}} - A(e_t)^{\frac{1}{1-\alpha}} = \left\{ \frac{g_c - \beta[1-\delta(1-\alpha)]}{\beta\alpha} \right\} A(e_t)^{\frac{1}{1-\alpha}} - \Theta e_t, \tag{28}$$

where $\Theta > 0$ is a constant. Let us define the first element on the right hand side of expression (28) as $\Psi(e_t)$ and compute its derivative to obtain

$$\Psi'(e_t) = \left\{ \frac{g_c - \beta[1-\delta(1-\alpha)]}{\beta\alpha(1-\alpha)} \right\} \left[\frac{\epsilon_A A(e_t)^{\frac{1}{1-\alpha}}}{e_t} \right].$$

The limits of $\Psi'(e_t)$ are given by

$$\lim_{e_t \to 0} \Psi'(e_t) = \begin{cases} +\infty & \text{if} \quad \epsilon + \alpha < 1, \\ 0 & \text{if} \quad \epsilon + \alpha > 1, \\ \mathrm{M}_1 & \text{if} \quad \epsilon + \alpha = 1, \end{cases}$$

and

$$\lim_{e_t \to +\infty} \Psi'(e_t) = \begin{cases} 0 & \text{if} \quad \epsilon + \alpha < 1, \\ +\infty & \text{if} \quad \epsilon + \alpha > 1, \\ \mathrm{M}_2 & \text{if} \quad \epsilon + \alpha = 1, \end{cases}$$

where M_1 and M_2 are two constants.

We plot the curves corresponding to the functions $\Psi(e_t)$ and Θe_t in Fig. 6. A steady-state of the competitive economy is a situation where the functions $\Psi(e_t)$ and Θe_t cross implying that $A(e_{t+1})^{\frac{1}{1-\alpha}} - A(e_t)^{\frac{1}{1-\alpha}} = 0$ or, equivalently, $e_{t+1} = e_t = e$. This can only occur if $\epsilon_A + \alpha < 1$ or $\epsilon_A + \alpha > 1$. From Fig. 6 it is straightforward to conclude that in the case where $\epsilon_A + \alpha < 1$ the steady-state is locally-stable, whereas in the case where $\epsilon_A + \alpha > 1$ the steady-state is unstable. Formally, by applying the implicit function theorem to (28), we obtain that at the steady state:

$$\frac{de_{t+1}}{de_t} = 1 + (1-\alpha)e \left[\frac{\Psi'(e) - \Theta}{\epsilon_A A(e)^{\frac{1}{1-\alpha}}} \right],$$

which is smaller than one if and only if $\epsilon_A + \alpha < 1$ because $\Psi'(e) < \Theta$ in this case.

When $\epsilon_A + \alpha = 1$, there is no positive steady-state but a BGP equilibrium where endogenous variables grow at constant rates. However, as can be observed from Fig. 6, two cases should be distinguished. We first rewrite expression (28) as

$$\left[\frac{A(e_{t+1})}{A(e_t)} \right]^{\frac{1}{1-\alpha}} - 1 = \left\{ \frac{g_c - \beta[1-\delta(1-\alpha)]}{\beta\alpha} \right\} - \frac{\Theta e_t}{A(e_t)^{\frac{1}{1-\alpha}}}.$$

Since in this case $\epsilon_A + \alpha = 1$, the last term on the right hand side is a constant. We can then conclude that $g_e > (<)1$ if and only if

$$\left\{ \frac{g_c - \beta[1-\delta(1-\alpha)]}{\beta\alpha} \right\} A(e_t)^{\frac{1}{1-\alpha}} > (<) \Theta e_t.$$

When $g_e > 1$, the curve $\Psi(e_t)$ is always above Θe_t while the converse is true when $g_e < 1$.

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